Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

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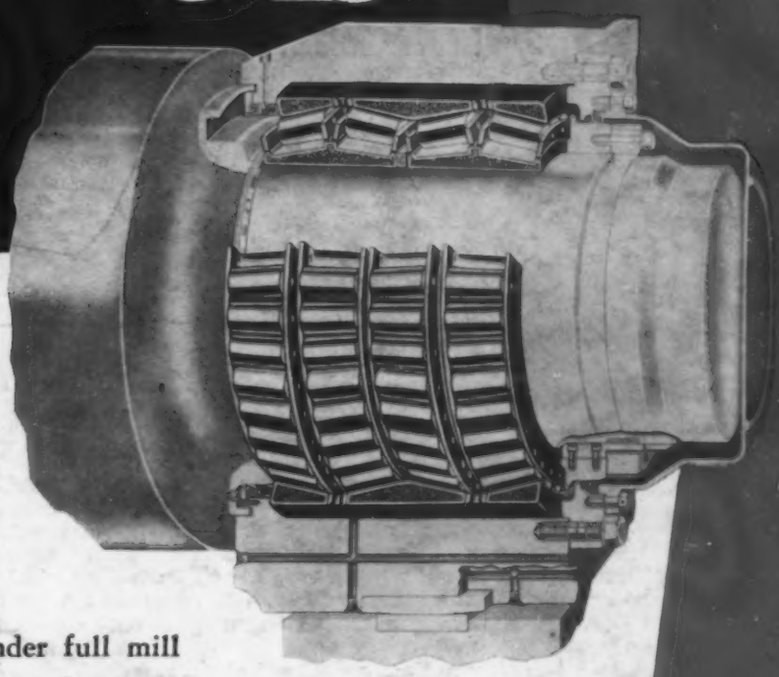
NOVEMBER, 1947

STOP-GO

WITHOUT LOSS OF TIME OR MATERIAL!



Routine mill stoppages present no difficulties where Timken Roll Neck Bearings are used. It is not necessary to relieve roll pressure when re-starting, therefore no material is wasted and no production time lost.

Roller bearings respond instantly under full mill load because they are *true anti-friction bearings.* Thus the momentary absence of a film of lubricant between the contact surfaces in the load zone does not affect their free-rolling characteristics. They would start just as quickly and easily under load if they were bone dry. This cannot be said of other types of roll neck bearings.

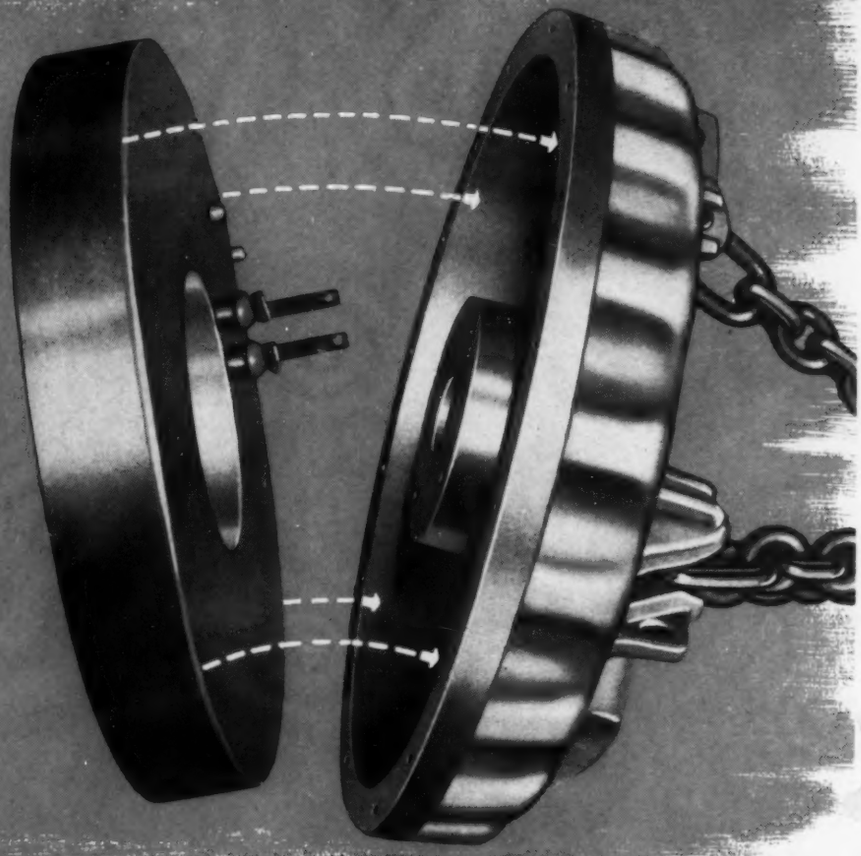
There is now no need to pass up this important roller bearing advantage—since Timken Balanced Proportion Bearings add 50% to 60% to the maximum neck strength afforded by earlier designs of roller bearings. For specific application data consult your mill builder or Timken roll neck bearing engineers. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
ROLL NECK BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▱ BEARING TAKES RADIAL ◫ AND THRUST —◫— LOADS OR ANY COMBINATION ✳

Now! New CAPSULE-COIL Magnet Construction

FOR LONGER LIFE AND EASY ON-THE-JOB COIL REPLACEMENT

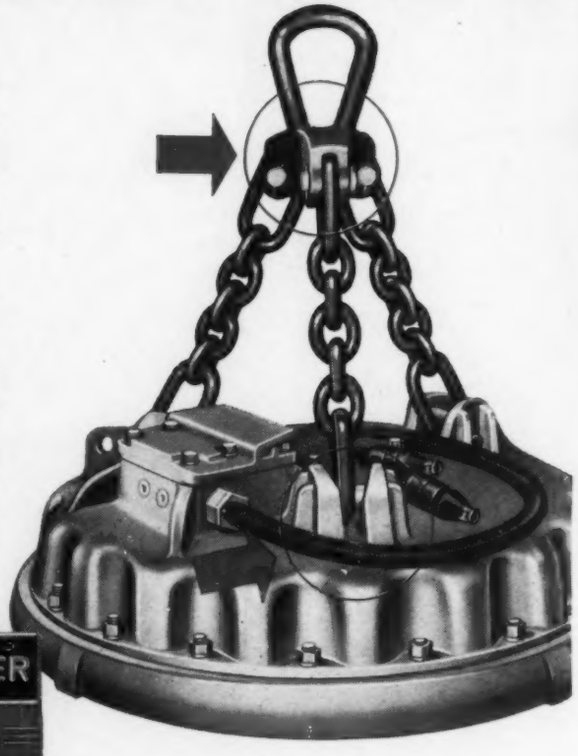


Now! New anti-wear features prolong chain life

Cutler-Hammer Supermagnets now embody a new welded, steel-sheathed CAPSULE-COIL sealed against moisture. With this new design plus removable pole shoes *YOU CAN REPLACE A COIL* easily, quickly and with a minimum of "time-out". For coil repairs, only the CAPSULE-COIL need be returned to the manufacturer. With a spare CAPSULE-COIL replacement, your Supermagnet goes back to work at once.

Also NEW, a radically different chain suspension, replacing the conventional top link with a new "non-twist", anti-wear yoke. This, plus redesigned, streamlined body lugs, materially eliminates trouble at the spots where chain usually wears out.

These major Cutler-Hammer advances match other Supermagnet features . . . high permeability steel spool, part of magnetic path . . . strap copper windings insulated by impregnated asbestos ribbon . . . high dielectric, bonded, mica discs between coil layers and CAPSULE case . . . tung oil impregnation . . . pressurized baking process. These superiorities—the result of 50 years of engineering leadership—merit your selection of "Cutler-Hammer" for your next magnet requirement . . . CUTLER-HAMMER, Inc., 1257 St. Paul Ave., Milwaukee 1, Wisconsin.



CUTLER-HAMMER
SUPERMAGNETS
C-H

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States, $8.25 Canada, $10.00 foreign countries. Volume 24, No. 11.

A E T N A · S T A N D A R D

did you ever see a
MULTIPLE SLITTING & SIDE TRIMMING LINE
With all these innovations?

COIL UNLOADING DEVICE

This coil unloading device permits unloading of one strand or more as desired. Installed at tension reel, the unloader saves many hours of handling time . . . fast, efficient, and compact.

1

TENSION REELS

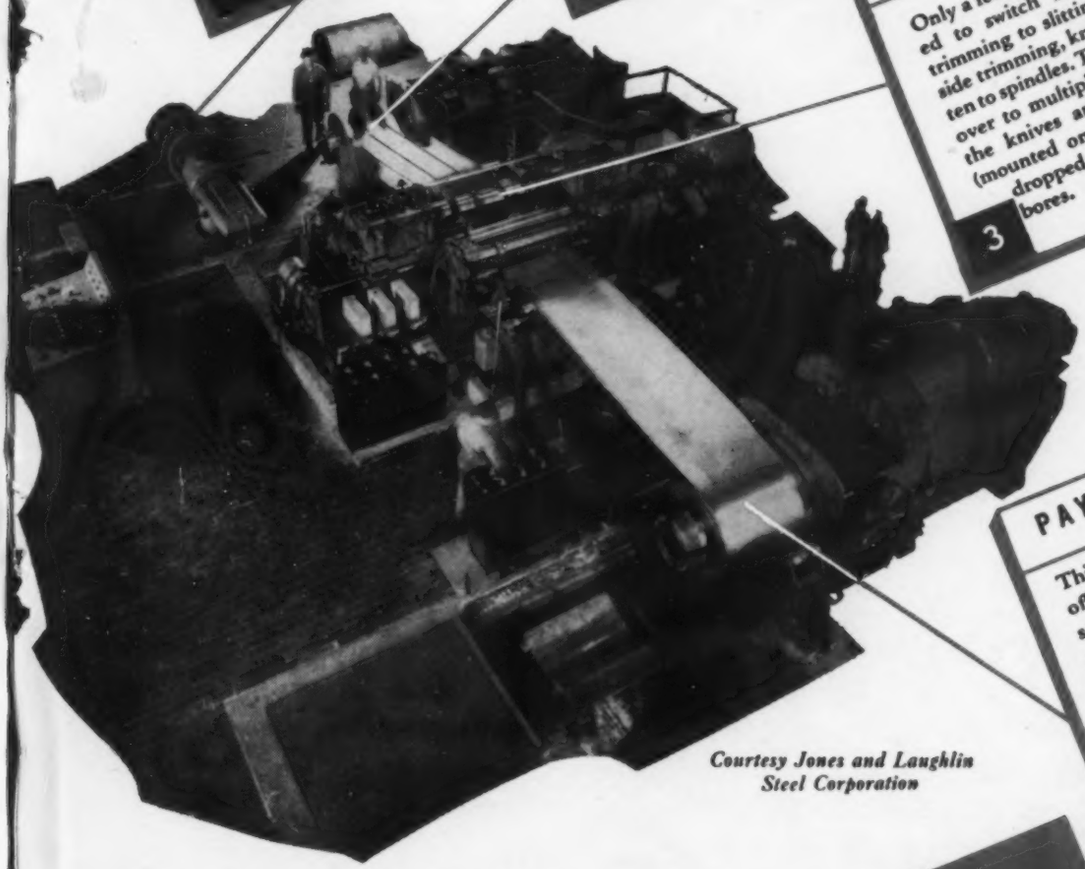
Here's something new in tension reels. Coils of 16" I. D. and 20" I. D. are handled with the Aetna-Standard tension reel on this line.

2

QUICK SWITCH-OVER

Only a few minutes needed to switch from side trimming to slitting. For side trimming, knives fasten to spindles. To change over to multiple slitting, the knives and spacers, (mounted on arbors) are dropped into tapered bores.

3



Courtesy Jones and Laughlin Steel Corporation

PAY-OFF REEL

This mandrel-type pay-off reel, with removable segments, handles 3 sizes of coils . . . 20" - 24" - 30" dia. Here again, many hours production time can be gained in change-over operations.

4

Sizes—Side Trimming and Multiple Slitting cold reduced coils up to 48" max. in gauges .017 to .109. *Max. Wt.*—22,000 lbs. *Speeds*—250 to 1,000 ft. per min. *Advantages*—(a) fast handling; (b) easy threading and operating; (c) quick unloading; (d) more production time—less man hour waste.

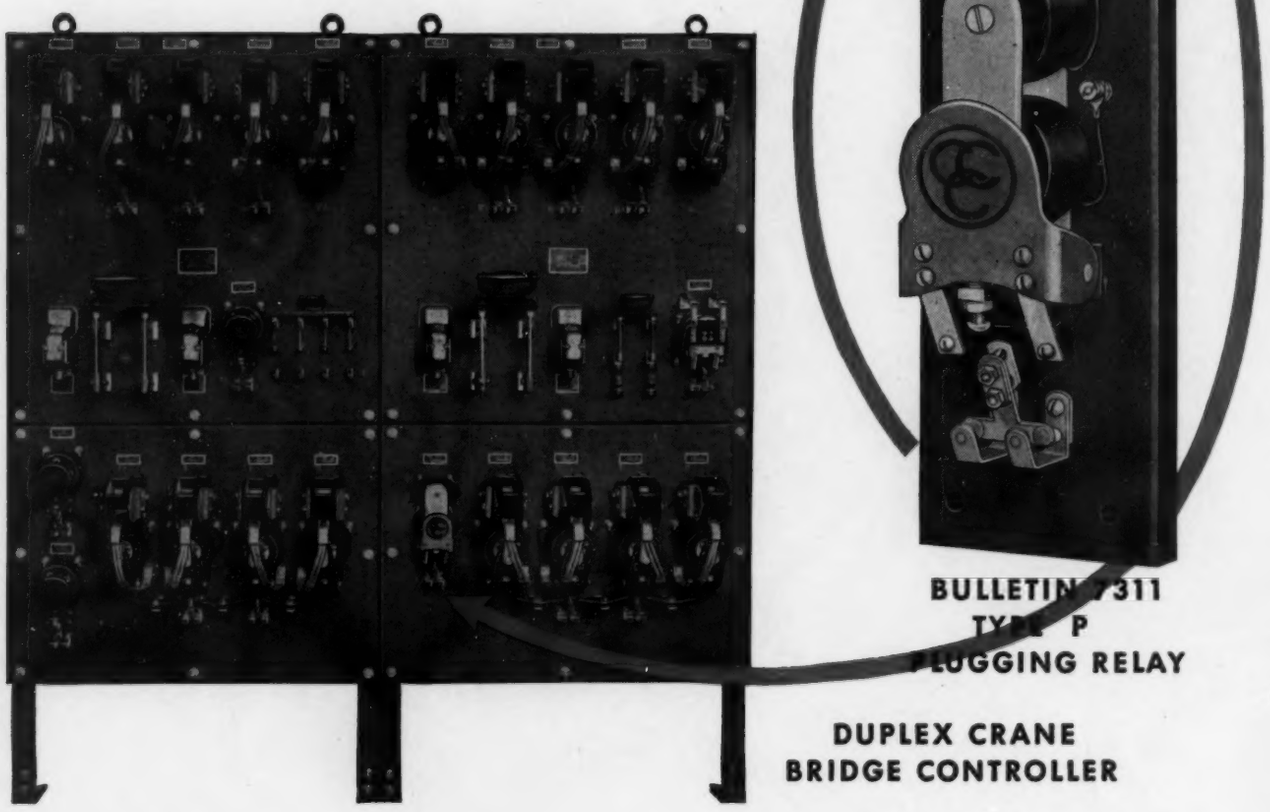
In addition to the four major innovations, this line has many other unique features. And Aetna-Standard sales engineers, upon request, will be glad to discuss your requirements.

THE AETNA-STANDARD ENGINEERING CO.
YOUNGSTOWN, OHIO

ASSOCIATED COMPANY:
HEAD, WRIGHTSON & CO., LTD., THORNABY-ON-TEES, ENGLAND

That CLARK Relay does it!

Simplicity Plus! For the vitally important operation of "plugging"— two identical shunt coils and a set of normally open contacts, duplicating all other circuit control contacts on the panel, are found in Bulletin 731 Type P Plugging Relays.



In starting from rest, the bottom coil predominates, and the relay closes immediately. However, during "plugging" the top coil has the counter EMF of the motor applied to it in a direction to neutralize the bottom coil. Thus the relay is blocked open until zero speed is reached. At that time, the bottom coil again takes command and the relay closes.

These relays provide accurate, dependable "plugging" operation by a simple easily understood device for such D. C. drives as Crane Bridges, Mill Tables, Manipulators, etc.

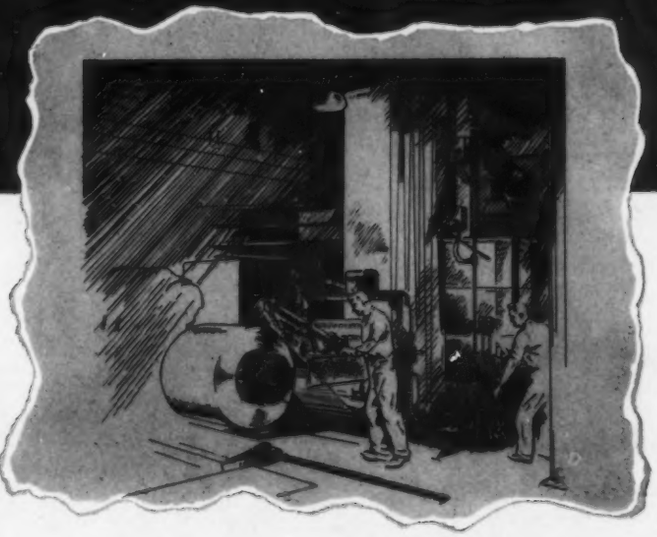
Clark Standardized Crane Bridge and Trolley Control now available in 6 to 8 weeks delivery.

THE CLARK CONTROLLER CO.

EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO

MESTA *electrolytic*

CLEANING LINES

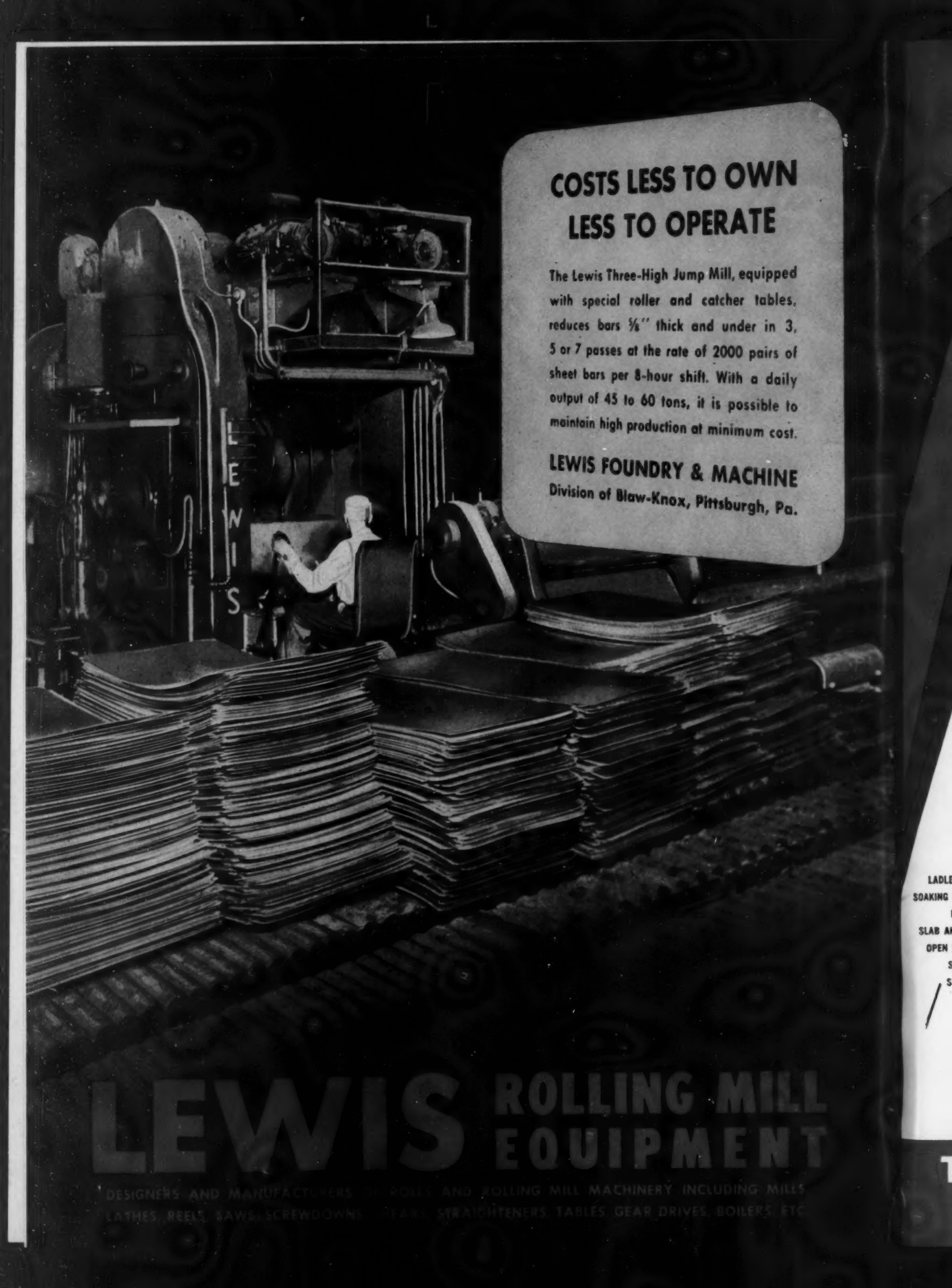


Battery of Five 42" Mesta High Speed Electrolytic Cleaning Lines . . . .

Assure Suitable Stock for the Electrolytic Tinning Operation.

DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

MESTA MACHINE COMPANY · PITTSBURGH, PA.


COSTS LESS TO OWN
LESS TO OPERATE
The Lewis Three-High Jump Mill, equipped with special roller and catcher tables, reduces bars ⅝" thick and under in 3, 5 or 7 passes at the rate of 2000 pairs of sheet bars per 8-hour shift. With a daily output of 45 to 60 tons, it is possible to maintain high production at minimum cost.
LEWIS FOUNDRY & MACHINE
Division of Blaw-Knox, Pittsburgh, Pa.
LEWIS
ROLLING MILL
EQUIPMENT
DESIGNERS AND MANUFACTURERS OF ROLLS AND ROLLING MILL MACHINERY INCLUDING MILLS
LATHES, REELS, SAWS, SCREWDOWNS, SHEARS, STRAIGHTENERS, TABLES, GEAR DRIVES, BOILERS, ETC.

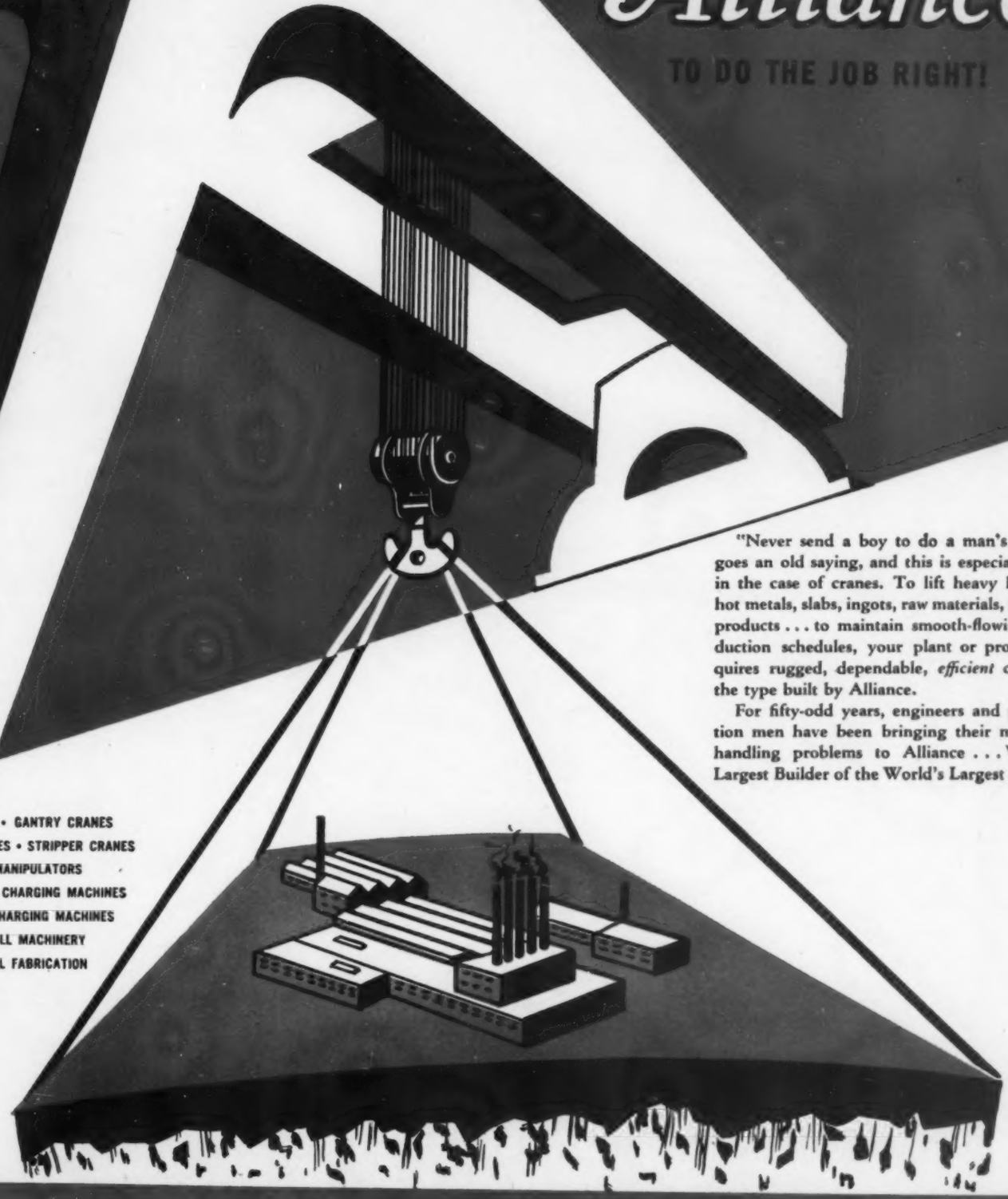
WHEN YOUR PLANT OR PROJECT NEEDS MORE

LIFTING POWER

Depend on

Alliance

TO DO THE JOB RIGHT!



"Never send a boy to do a man's work," goes an old saying, and this is especially true in the case of cranes. To lift heavy loads of hot metals, slabs, ingots, raw materials, finished products . . . to maintain smooth-flowing production schedules, your plant or project requires rugged, dependable, *efficient* cranes—the type built by Alliance.

For fifty-odd years, engineers and production men have been bringing their materials handling problems to Alliance . . . World's Largest Builder of the World's Largest Cranes.

LADLE CRANES • GANTRY CRANES
SOAKING PIT CRANES • STRIPPER CRANES
FORGING MANIPULATORS
SLAB AND BILLET CHARGING MACHINES
OPEN HEARTH CHARGING MACHINES
SPECIAL MILL MACHINERY
STRUCTURAL FABRICATION

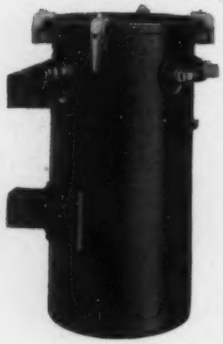
THE ALLIANCE MACHINE COMPANY

MAIN OFFICE:
ALLIANCE, OHIO • PITTSBURGH OFFICE:
1622 OLIVER BUILDING, PITTSBURGH, PA.

Pennsylvania
... an important name in transformers

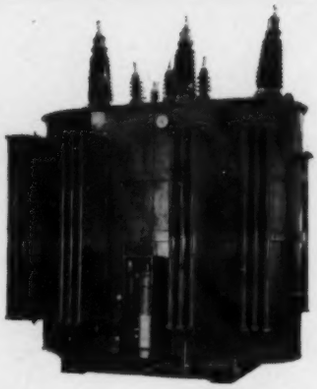
It's a fact that Pennsylvania Transformers are making friends all over the country by giving good, honest service. We believe one of the major reasons for this is the special emphasis placed by Pennsylvania on research and development work, which has resulted in the introduction of many important improvements, such as the Straight Line Tap Changer, Uni-Row Radiators, and Precompressed Coils.

If you are in the market for transformers, you'll do well to consider Pennsylvania. The Pennsylvania Representative nearest you will be glad to review your transformer problems and discuss Pennsylvania's complete line of Distribution and Power Transformers.



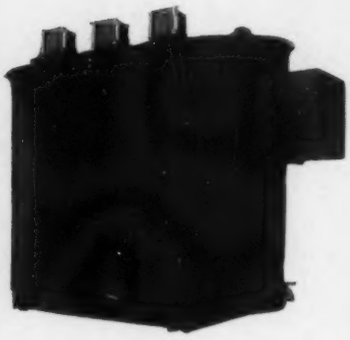
3 Kva. Typical through 25 Kva.

DISTRIBUTION
3 Kva to 500 Kva. Up to 66,000 volts.



7500 Kva, 3 Phase, 60 Cycles 115,000-34,500/19,-900 volts.

POWER
667 Kva to 50000 Kva. Up to 165,000 volts.

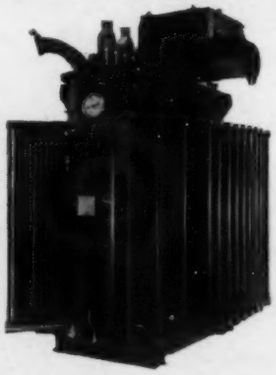


15,000 Kva with motor operated tap changer.

FURNACE
Up to 20,000 Kva

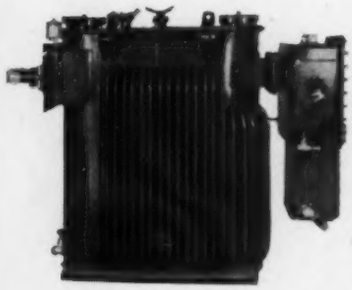
1000 Kva, 3 Phase, 60 Cycles 12,000-480 volts.

DRY TYPE
Natural and Forced Air Cooled.



3000 Kva, 3 Phase, 25 Cycles 13,800-480 volts.

ASKAREL
Distribution and Power sizes.



450 Kva, 3 Phase 22,000-208 volts.

NETWORK
Indoor or street vault installation.

WRITE FOR FREE COPIES
of our eight page booklets, "4 Minutes with Pennsylvania Transformers", "Ask for Askarel".

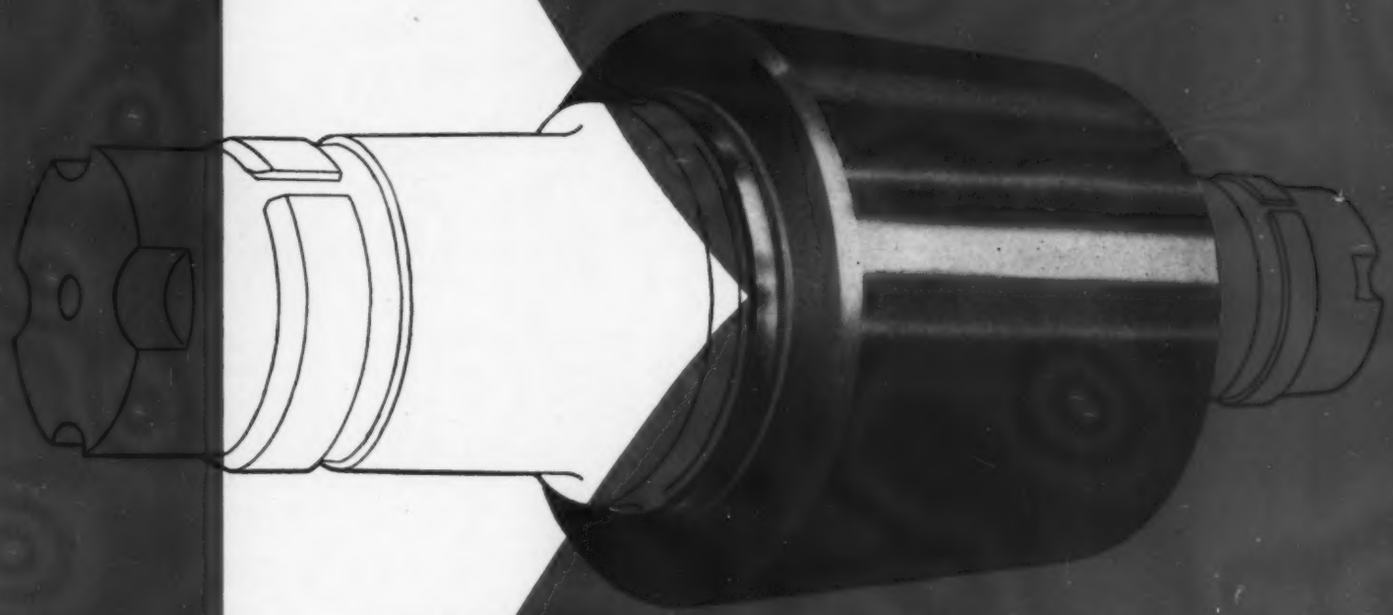
Pennsylvania
TRANSFORMER COMPANY
PITTSBURGH, PENNSYLVANIA

Pennsylvania TRANSFORMERS

3 Main Reasons Why—

Heppenstall Sleeves

cut back-up roll costs



1. *First Cost is Lower*—Heppenstall forged-steel sleeves cost less than solid rolls and are furnished from alloy steel of our own manufacture.

2. *They Last Longer*—Heppenstall sleeves provide working surfaces which outlast solid rolls because they are "tailor-made" and heat treated to the hardness required for any specific application.

3. *They Save Worn Rolls*—Why scrap a worn back-up roll when it can be re-sleeved several times? Heppenstall has every facility for correctly sizing your solid rolls to form arbors . . . and for perfect shrink-fitting of sleeves to arbors.

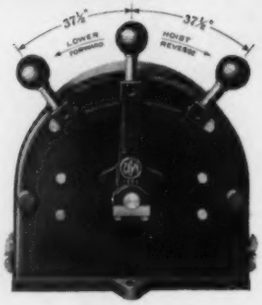
If you are interested in greater tonnage at lower cost, investigate the advantages of Heppenstall sleeves. And remember, too, that Heppenstall produces forged arbors—also "tailor-made" as to both material and strength for extra service. Write Heppenstall Company, Pittsburgh 1, Pa.

the most dependable name in forgings— **Heppenstall**

CAM MASTER SWITCH

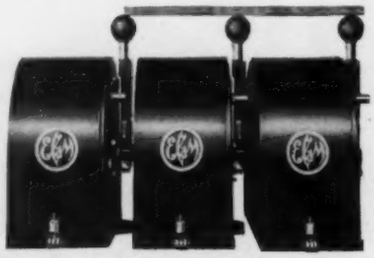
★ *Gives Improved Performance where SPEED-CONTROL is desired . . . .*

The EC&M Cam Master Switch is used by many plants to obtain speed-control of crane and mill-auxiliary drives and similar applications where magnetic control is employed.



Short throw saves motion of operator's arms—reduces fatigue.

Standard 6-point, 12-circuit Master Switch.



Narrow width gives short-center mounting—keeps handles within easy reach of operator where several Master Switches are controlled by one operator.

Cover forms one side of enclosure and, when removed, makes all parts accessible.

For this service, these Master Switches have outstanding advantages, the more important being—

Easy on the Operator

1. Handle on 6-point Master travels only 37½° from off-position to full on position in either direction. Throw is 6° less for each speed-point reduced—31½° for 5-points, 25½° for 4-points, etc.
2. Narrow width allows close grouping of operating handles where one operator has more than one Master Switch to manipulate—12-circuit Masters mount on 9-inch centers, 8-circuit on 7⅞-inch centers and 16-circuit on 10⅛-inch centers.
3. Roller-arm centering-device gives definite feel to all points—off-position is most prominent, yet is so shaped to permit easy inching operations between off and first points in either direction.

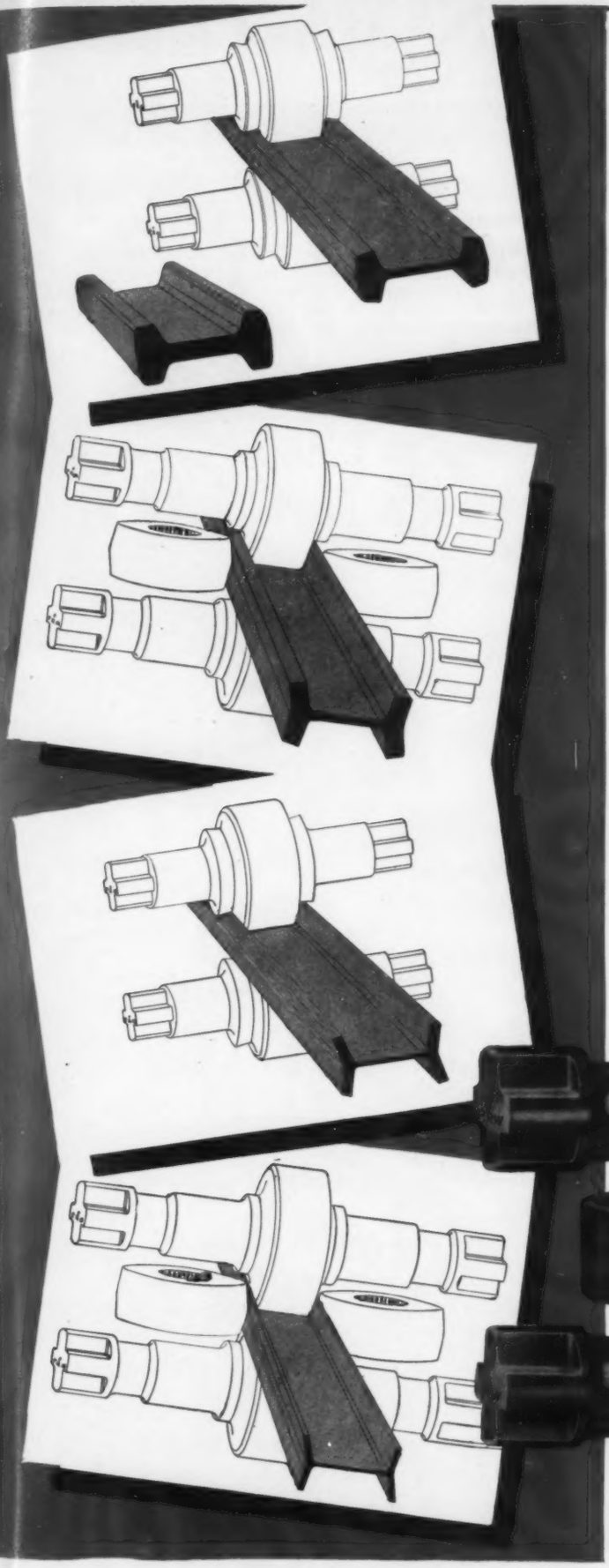
Convenient to Wire

1. L-shaped frame allows maximum accessibility to all parts when cover is removed.
2. Generous room for pulling in wires and making connections to terminal studs, which are equipped with cup washers and locking nuts.
3. Tapped conduit hole in middle of base brings leads in at bottom close to studs.

Specify EC&M Bulletin 1190 Cam Master Switches for cranes, and mill auxiliaries, ore bridges, and similar applications.

THE ELECTRIC CONTROLLER & MANUFACTURING CO.
2698 EAST 79th STREET CLEVELAND 4, OHIO

ROLLING TECHNIQUE . . .

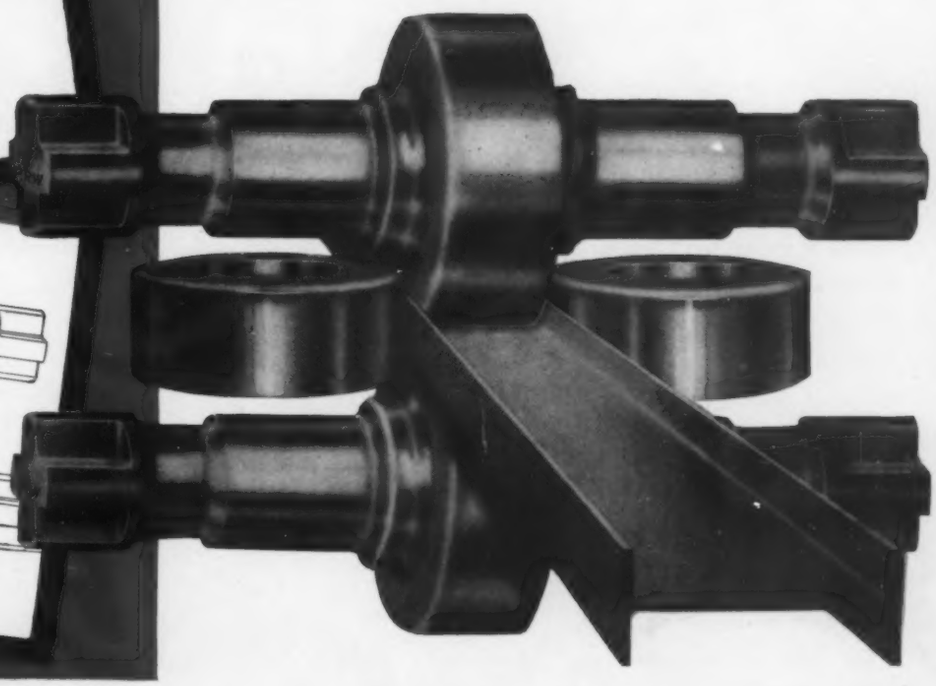


Universal Beam Mills

Although there are very few mills of this type in this country, the tonnage of large beams and large H beams with parallel flanges is counted in the thousands. These mills afford the only means by which these larger sections can be rolled. Here again proper rolls play a large part in producing a quality product.

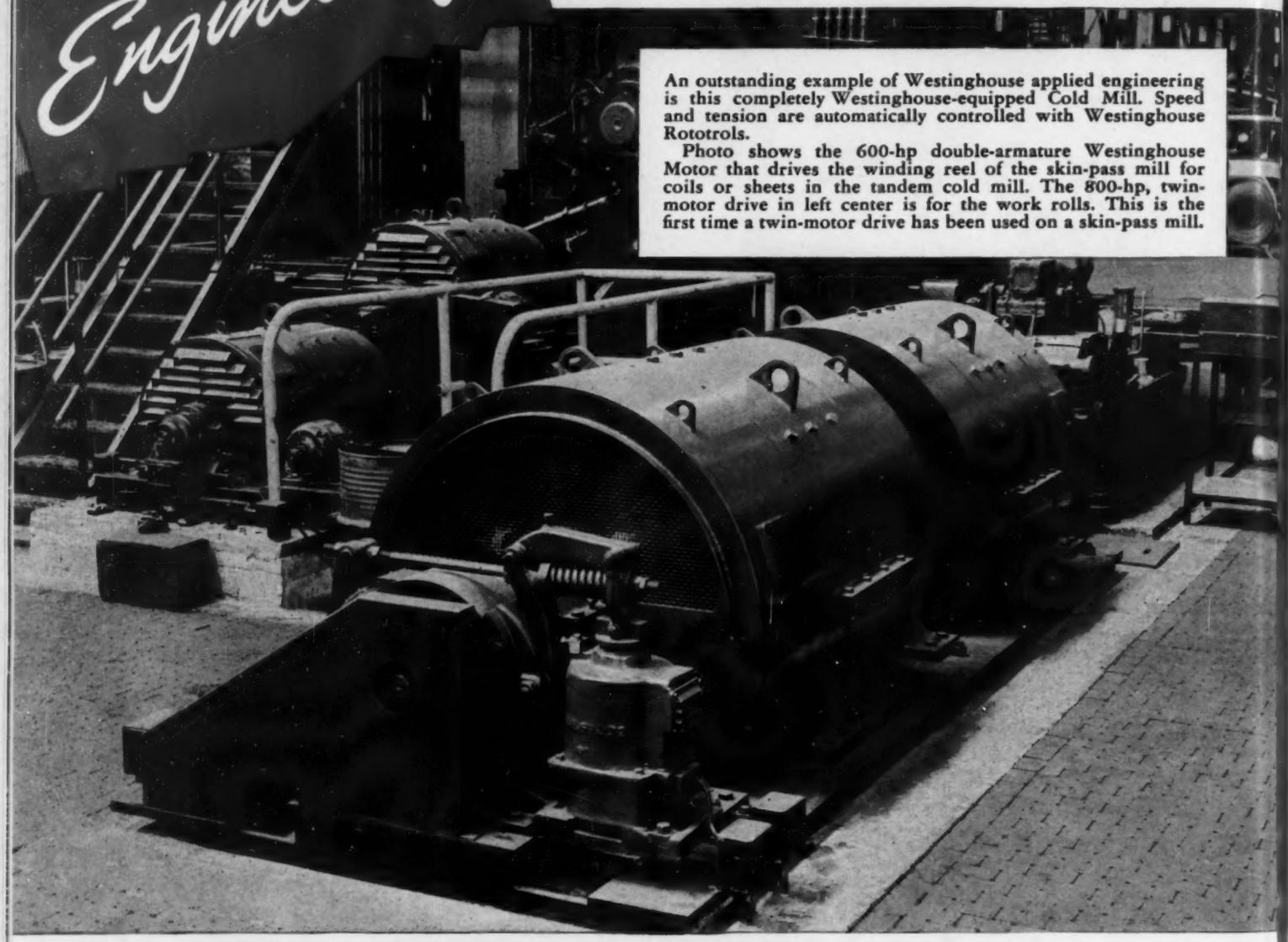
Pittsburgh Rolls are made by skilled craftsmen whose thorough practical knowledge of metallurgy, foundry methods and accuracy in roll turning is the accumulated result of over seventy-five years devoted to the exclusive manufacture of rolling mill rolls. The use of Pittsburgh Rolls can result only in *less cost per ton of steel rolled.*

PITTSBURGH ROLLS
Division of Blaw-Knox Company
PITTSBURGH, PA.



PITTSBURGH ROLLS

Applied Engineering TO BRING YOU MORE



An outstanding example of Westinghouse applied engineering is this completely Westinghouse-equipped Cold Mill. Speed and tension are automatically controlled with Westinghouse Rototrols.

Photo shows the 600-hp double-armature Westinghouse Motor that drives the winding reel of the skin-pass mill for coils or sheets in the tandem cold mill. The 800-hp, twin-motor drive in left center is for the work rolls. This is the first time a twin-motor drive has been used on a skin-pass mill.

WESTINGHOUSE CONTRIBUTIONS TO THE STEEL INDUSTRY

Today's mechanized steel mills owe much of their operating efficiency to important Westinghouse developments, worked out in co-operation with steel mill engineers.

Many of these contributions are a matter of record, and include:

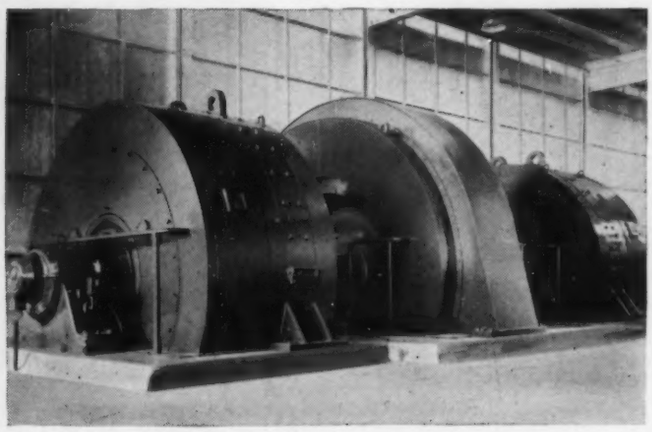
- **the first installation of electric motors in a steel mill in this country**
- **the first large, single-unit, reversing mill main drive motor**
- **the first tensiometer**
- **the first large, twin-motor, reversing mill drive**
- **the fundamental method of controlling electric arc furnaces**
- **the first complete line of arc furnace control**

Let Westinghouse applied engineering work for you . . . in the correct use of electrical apparatus for most efficient plant operation . . . in the development and application of new methods and equipment for your specialized requirements. Complete layout drawing service for mill setups—tailor made to solve your problems—with recommended types and sizes of equipment, is available. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-94770

PRODUCTIVE POWER

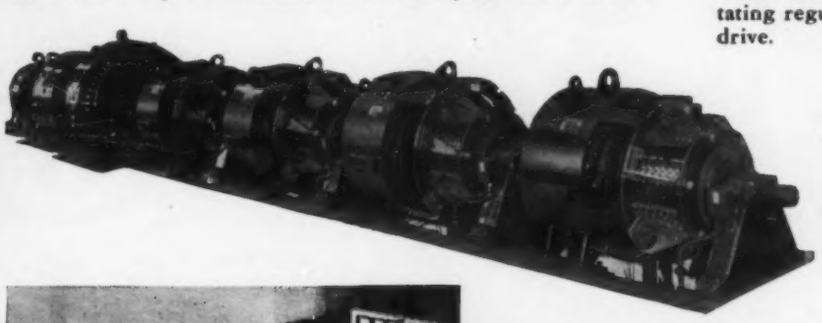
FROM PLANNING BOARD TO PRODUCT, HERE'S HELP IN PRODUCING FASTER, CHEAPER, BETTER ELECTRICALLY

This broad engineering service is an important *plus* to consider when you buy electrical equipment. A complete and separate Westinghouse Steel Industry Department, staffed by competent engineers intimately acquainted with steel and metal-working problems, assures the prompt and practical application of new Westinghouse developments to your special production techniques.



8,000-kw, synchronous m-g set for the tandem mill. The 11,200-hp, 300-rpm, 90% pf Westinghouse Synchronous Motor in the center drives two 4,000-kw, 720-volt, d-c generators. System power factor is automatically controlled by a Rototrol regulator which adjusts the excitation of the synchronous motor.

Main roll drive motors for the tandem mill. In the background is a 2,000-hp, Westinghouse Motor for stand 1, next a 2,500-hp motor for stand 2 and two 3,000-hp, twin-motor drives for stands 3 and 4. In right foreground is a 600-hp, double-armature motor for tension reel, and in left foreground are Rototrol rotating regulators and exciters for mill motors and tension reel drive.



This IR drop compensator assures a constant speed, regardless of load, at any voltage adjustment from threading to running voltage. The four d-c booster generators on the right are driven by the 800-hp, Westinghouse Motor, third from left.

One of seven 750-kva, Westinghouse Power Centers for low-voltage power in the tandem mill. Transformer is Inerteen cooled. Feeder circuits are protected by 1,200-ampere "draw-out" type air circuit breakers.

Three-ton coil being transferred from pickling line conveyor, visible in background. A 100-hp, Westinghouse Mill-type Motor drives the main hoist of this 40-ton crane. Westinghouse control for hoist, bridge and trolley is housed in metal cabinets, two of which appear at left.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

MORE PRODUCTIVE POWER FOR INDUSTRY

Four Letters that Spell Circuit Failure

. . . and what to do about it!

If you can't detour hot-spots *don't guess.* Take thermal readings of circuits that run near boilers, furnaces, soaking pits, steam lines and other heat-generators. And make sure that the wire or cable you use has ample heat resistance to stand up in the *torrid zones* that bake up failures.

Steel mills, refineries, power companies and manufacturing plants that have high-temperature wiring problems use Rockbestos A.V.C. because they know it won't bake brittle, crack or flow under operating temperatures ranging as high as 230°F. They know, too, that corrosive fumes, grease or oil won't shorten its life because *impregnated asbestos* won't rot or bloom. And they also know from experience that it withstands destructive heating and cooling cycles in conduit installations where other types had to be replaced frequently.

You get these circuit-protecting advantages *plus* greater current carrying capacity in Rockbestos A.V.C.—the insulation that takes re-wiring expense out of circuit maintenance. 600 to 5,000 volt ratings include lighting and switchboard wires, lead sheathed or armored power and control cables and National Electrical Code types. Write our nearest district office for information or recommendations.

ROCKBESTOS PRODUCTS CORPORATION, 608 Nicoll Street, New Haven 4, Conn.

NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO
PITTSBURGH ST. LOUIS LOS ANGELES OAKLAND, CAL.

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

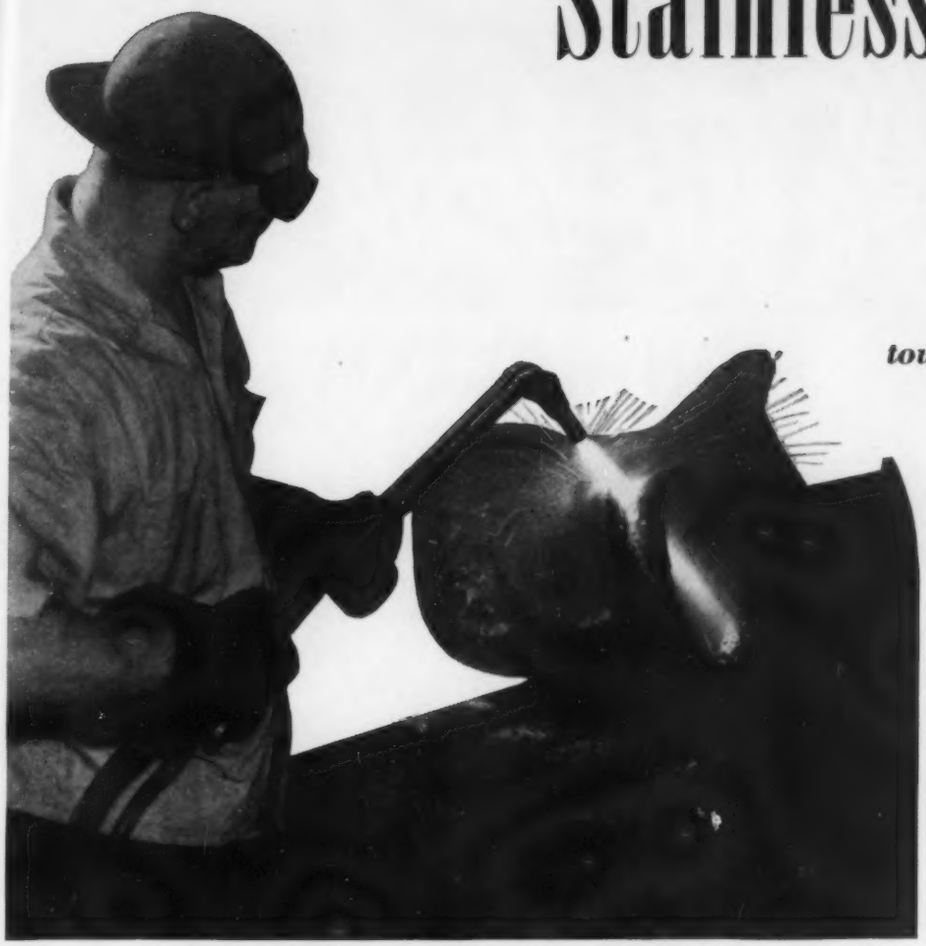
A TYPICAL ROCKBESTOS CONSTRUCTION DESIGNED FOR SEVERE CONDITIONS

Type AVA Rockbestos A.V.C. 600 Volt Power Cable illustrated (No. 18 AWG to 2,000 MCM) and similarly insulated Motor Lead Cable have a maximum operating temperature of 230°F., and this failure-preventing construction:

- Age-resistant impregnated asbestos braid resists heat, flame, moisture, oil, grease and corrosive fumes.
- Outer wall of felted asbestos insulation, impregnated with heat, flame and moisture resisting compounds, won't dry out, crack, flow, rot or burn.
- Asbestos-protected varnished cambric for high dielectric strength and added moisture resistance.
- Inner wall of impregnated felted asbestos withstands conductor-heating overloads—won't bake brittle or burn and helps provide greater current carrying capacity.
- Conductor is perfectly and permanently centered in helically applied non-flowing insulation.

One of 125 different constructions designed by Rockbestos for severe or unusual operating conditions in ratings from 600 to 5000 volts.

Stainless Steel is TOUGH



tough to cut, too—but LINDE makes the job easier . . . just as easy as cutting carbon steel

LINDE's powder-cutting process overcomes the barrier to fast and economical cutting of stainless or chromium steels.

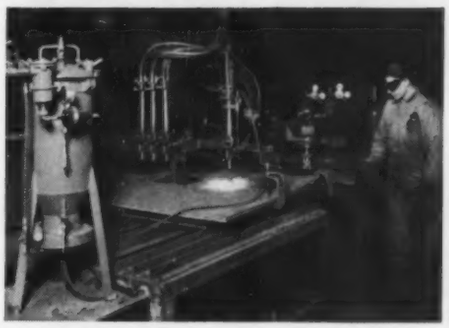
By means of easily installed attachments for standard oxy-acetylene equipment, powder-cutting can be done without substantial change from carbon steel cutting techniques.

IN FOUNDRIES—

by powder-cutting, risers are removed 20 times faster than by older methods. Removal of riser pads and gouging out defects can be done at considerable savings in cost.

IN STEEL MILLS—

a 12,000-lb. ingot can be powder-scarfed in 4 to 6 hours—about 1/10 the time required for grinding. Sizing of ingots, billets, and slabs, removal of hot tops, scrapping operations, and many other cutting jobs can be done in a fraction of the time previously required.



IN FABRICATING PLANTS—

a stack of twelve 10-ga., type-304 stainless sheets were powder-cut at 8 in. per min. . . . 4-in. I.D. by 8-in. O.D. flanges on ½ in., type 316 plates were made in 2 minutes of cutting time apiece.

If you work with stainless steel you will want to know more about this LINDE process. LINDE can supply the equipment you need, help you to set up, and supply the training help you need.

Linde

The word "Linde" is a registered trade-mark of The Linde Air Products Company.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

Quick-As-Wink

CONTROL VALVES

Available in 2-way 3-way 4-way types
Exterior view of 2- and 3-way diaphragm valve.
1/2" 4-way neutral position hydraulic valve. Hydraulic valves in pressures up to and including 5000 lbs.
HAND
FOOT
CAM
DIAPHRAGM
PILOT CYLINDER
SOLENOID
OPERATED
1/2" 3-way, single solenoid, spring return valve.
1/2" 4-way mechanically operated, spring return valve. Air valves are available in pressures up to 250 lbs.

C. B. HUNT & SON, INC., SALEM, OHIO

THE HIGHER THE PRESSURE — AIR WATER OIL — THE TIGHTER THE SEAL

How Reliance V★S can help *you* meet the greatest challenge industry has ever faced

WAGES go up and up, along with materials and other manufacturing costs. But to keep America prosperous, prices cannot be permitted to spiral to the point where large numbers of consumers are forced out of the market. How to prevent this presents the greatest challenge industry has ever faced.

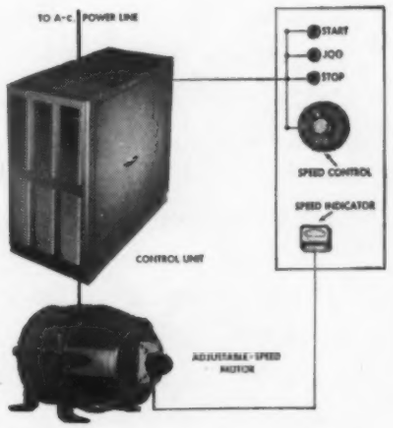
One sound answer is increased production through the use of more efficient machinery and methods. And this is where Reliance V★S can help you. *We have yet to find the industry where the V★S Drive cannot improve the quantity and quality of output, while lowering costs.*

A Reliance Application Engineer will survey your operations, then show you where and how you can benefit most through use of V★S—*the All-electric, Adjustable-speed Drive, operating from A-c. Circuits.* Just phone the nearest Reliance representative or write us direct for Bulletin 311.

RELIANCE ELECTRIC & ENGINEERING CO.
1084 IVANHOE ROAD • CLEVELAND 10, OHIO
Sales Representatives in Principal Cities

RELIANCE V★S DRIVE

Available in the Electronic System (1 to 5 hp.), in the Rotating System (1 to 200 hp.), or in a combination of both systems.

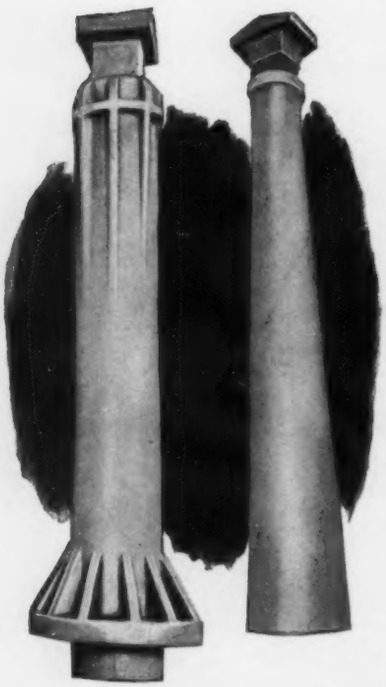


Reliance V★S Drive provides unlimited flexibility of machine operation. Starting, stopping, speed changing, reversing, maintenance of proper tension and other functions are exercised automatically or manually from nearby or remote stations.

RELIANCE A-C D-C MOTORS

THE "HINGES OF HELL" ARE LUKEWARM

. . . compared to the inferno of a modern open hearth furnace.
And, considering the recent advances in both temperatures and charging speeds,
Boxes and Peels must take greater punishment than ever before.



UNION *Alloy Steel* PEELS

Except for the charge itself, no piece of unprotected metal is subjected to greater heat for a longer time than the peel. And, hot or cold, it must withstand severe shock and stresses as well. "Union" has developed for this tough service peels of heat and shock resistant alloys in designs that add months to their useful life . . . Glad to quote from your specifications on either rough or fully machined castings.

UNION *Double Life Head* CHARGING BOXES

Open hearth furnace superintendents who are out for record tonnage will recognize the evident advantages of Union Boxes. That specially designed, reinforced head means "double life" without cracking or distortion . . . All square corners have been replaced by round ones which lend themselves to better casting process . . . Union Boxes are cast from UNIVAN — a special nickel-vanadium steel that maintains its superior strength under extreme conditions of heat, cold and shock . . . Whether you operate with 20, 25, 36 or even 50 cu. ft. capacity, we welcome the opportunity to prove that you can do a faster charging job for a longer time at less cost with Union Double Life Head Boxes . . . Your requests for further details and prices will receive immediate attention.

"UNIVAN" Alloy Steel

UNION STEEL CASTINGS

DIVISION OF BLAW-KNOX CO., PITTSBURGH, PA.

Cinder Pots • Slag Pots • Coupling Boxes • Spindles • Gears • Bells and Hoppers • Ingot Cars • Charging Cars • Annealing Boxes and Bases

UNITED

4-STAND TINPLATE MILL

The canning industry—America's largest user of tinplate—depends largely upon progress in the development of new and better steel rolling and coating processes to broaden its ever growing usefulness to the public.

One step in the process of making better tinplate for canning is the giant new United mill shown in operation. Designs for this, and other mills with production speeds up to 5000 feet per minute, are available for duplication, or for revision to suit your requirements. UNITED's engineers will be glad to confer with you concerning your plans for increased tinplate production.

U.E.&F.CO. REG. T. M.

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at Pittsburgh · Vandergrift · New Castle · Youngstown · Canton
Subsidiary: Adamson United Company, Akron, Ohio
Affiliates: Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal, P. Q. Canada

On the job **LONGER**

with **P-G...**

Continuous

TROUBLE FREE SERVICE

P-G *Steel Grid Resistors* built of steel and mica, coupled with exclusive features of design, make P-G Resistors capable of constant "Trouble Free" service. Specify P-G for maximum production with minimum maintenance.

P-G

The Nonbreakable Steel Grid Resistor

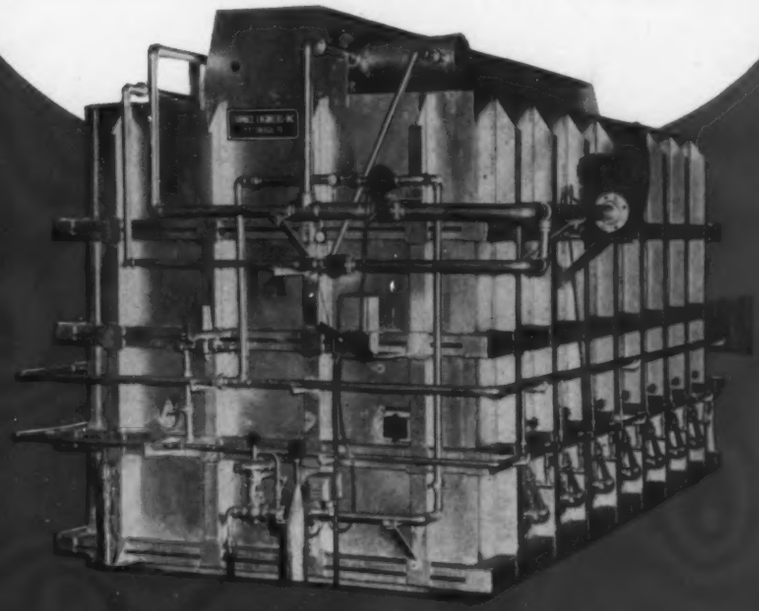
THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

Heat treating perfection

CONSISTENTLY PRODUCED BY F. E. I. FURNACES



Heat treating perfection — the providing of all desired characteristics in the speediest, most efficient manner — is yours when you employ F. E. I. equipment. Specialists in all phases of heat treating, Furnace Engineers, Inc. offer you the complete solution to any heat treating problem.

From original analysis and design, through manufacture and installation to supervisory operational check-ups, F. E. I. handles the entire equipment requirement. If you're having heat treating trouble, write today for full details of the help F. E. I. can give you.

F. E. I. EQUIPMENT

- Direct-Fired Cover Furnaces for annealing, spheroidizing, Normalizing and bright annealing of wire, rods, coiled strip, flat sheets and tin plate.
- For Heavy Coil Loads: Patented Convection Base, gives 2 to 4 times longer service.
- For Wire, Bar and Tube Mills: Galvanizing, Patenting and Normalizing furnaces.
- Car Type Furnaces, Rod Heating, Lead Quenching; Ladle Heating and Salt Bath Descaling Furnaces.
- Continuous, Quenching and Tempering Furnaces—Quench Tanks, Water or Oil.
- Soaking Pits.
- Special Application Furnaces for both ferrous and non-ferrous industries.

FURNACE ENGINEERS, *Inc.*

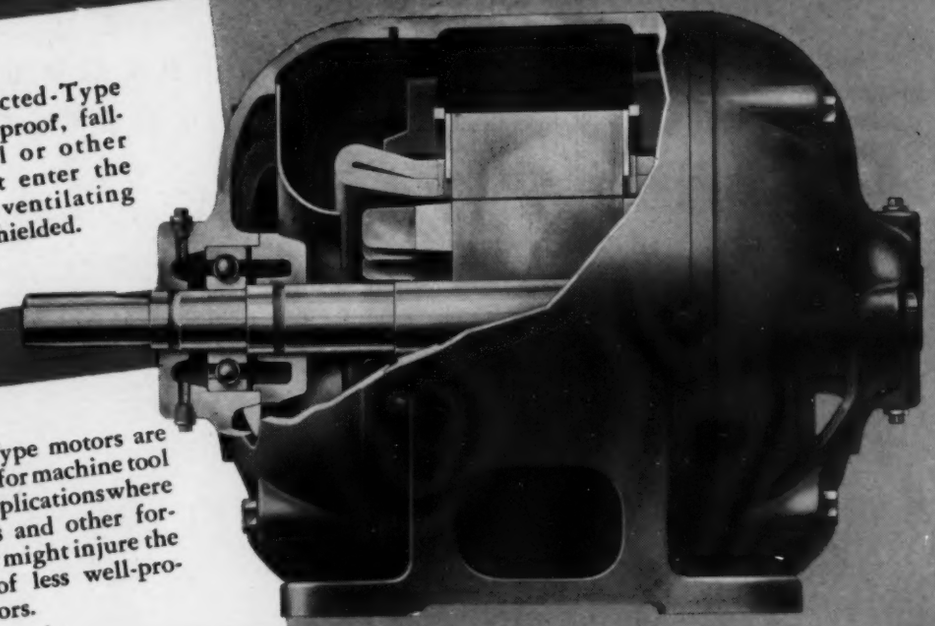
FOREIGN REPRESENTATIVES: For Canada: Salem Engineering (Canada) Ltd., Toronto, Ont. For Europe, Asia: Salem Engineering Co., Ltd., 124 Devonshire Street, Sheffield 1, England.

1551 WEST LIBERTY AVENUE ★ PITTSBURGH, PA.

When and Where you should use . . .

WHERE THERE IS DRIPPING LIQUID

Because Protected-Type motors are dripproof, falling water, oil or other liquids cannot enter the windings. All ventilating openings are shielded.



WHERE THERE ARE FALLING CHIPS

Protected-Type motors are tailor-made for machine tool and other applications where metal chips and other foreign matter might injure the windings of less well-protected motors.

WHEN INSPECTION VISITS ARE FEW AND FAR BETWEEN

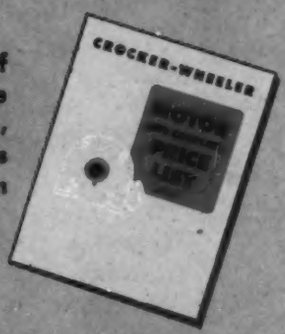
Because rotors are practically indestructible; because stator windings are dirt, oil and moisture resistant to a high degree; because bearing seals are so effective that regreasing is required only once a year or even less frequently — Protected-Type motors require *minimum maintenance.*

FOR ALL GENERAL-PURPOSE APPLICATIONS

Rated 40C rise, full-load continuous duty, with a 15 per cent overload factor, these motors are suitable for all general-purpose applications for horizontal, vertical or wall mounting. Available in standard ratings from 1 to 1000 hp.

CROCKER-WHEELER *protected-type* MOTORS

Ask for your FREE copy of new, handy, 8-page price list that gives prices, weights and dimensions of standard motors in sizes up to 75 hp.



Quality Motors and Generators Since 1888

YOU CAN GET FROM CROCKER-WHEELER:

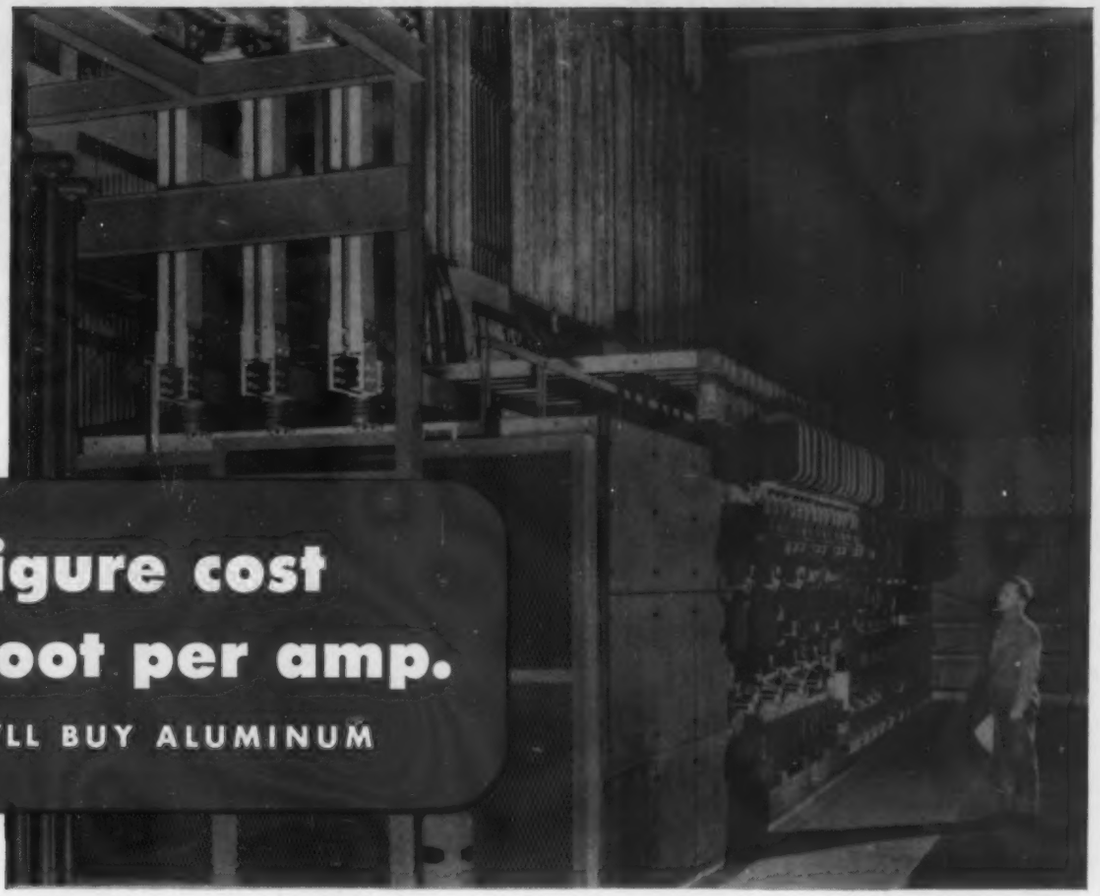
Polyphase Induction Motors, 1 to 10,000 hp.
Direct Current Motors, 1 to 5,000 hp.
Alternating Current Generators, 500 to 10,000 kva.
Turbo Generators, 1875 to 12,500 kva.
Direct Current Generators, 1 to 3000 kw.
Motor-Generator Sets, 1 to 6000 kw.
Flexible Couplings, for shaft diameters up to 8".

CROCKER WHEELER

ELECTRIC MANUFACTURING COMPANY, AMPERE, N. J.

A Division of Joshua Hendy Corporation

Branch Offices: Boston, Chicago, Cincinnati, Cleveland, Los Angeles, New York
Philadelphia, Pittsburgh — Representatives in Principal Cities



Alcoa Aluminum 6-inch Channel Bus installation working at 250 and 440 volts in The Jones & Laughlin Steel Corporation strip and sheet mill, Pittsburgh, Penna.

Figure cost per foot per amp.

...YOU'LL BUY ALUMINUM

You will pay less per foot per amp. for Alcoa Aluminum Bus Conductors than for any other metal. And you'll save on fabrication and erection costs.

Alcoa Aluminum Bus Conductors are designed to resist deformation under abnormal stresses, have high electrical efficiency to carry large currents without overheating.

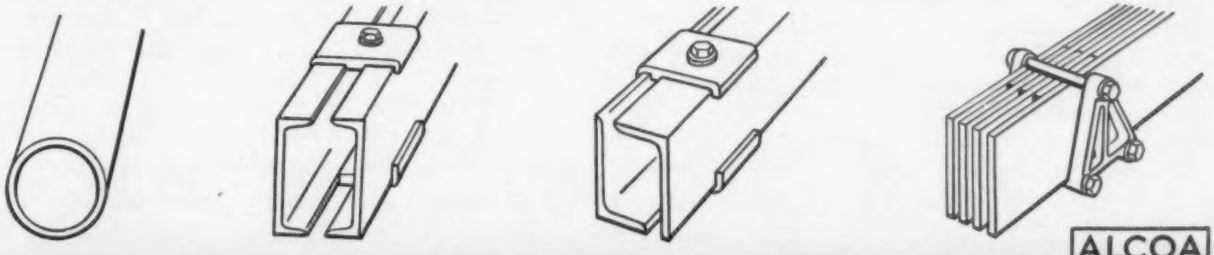
Write today for engineering data and information on Alcoa Aluminum Bus Conductors. ALUMINUM COMPANY OF AMERICA, 2128 Gulf Bldg., Pittsburgh 19, Pennsylvania. Sales offices in 54 leading cities.

LIGHTER
. . . less dead load, lower freight costs, lower handling and erection costs.

AVAILABILITY
. . . prompt delivery. Many sizes in stock.

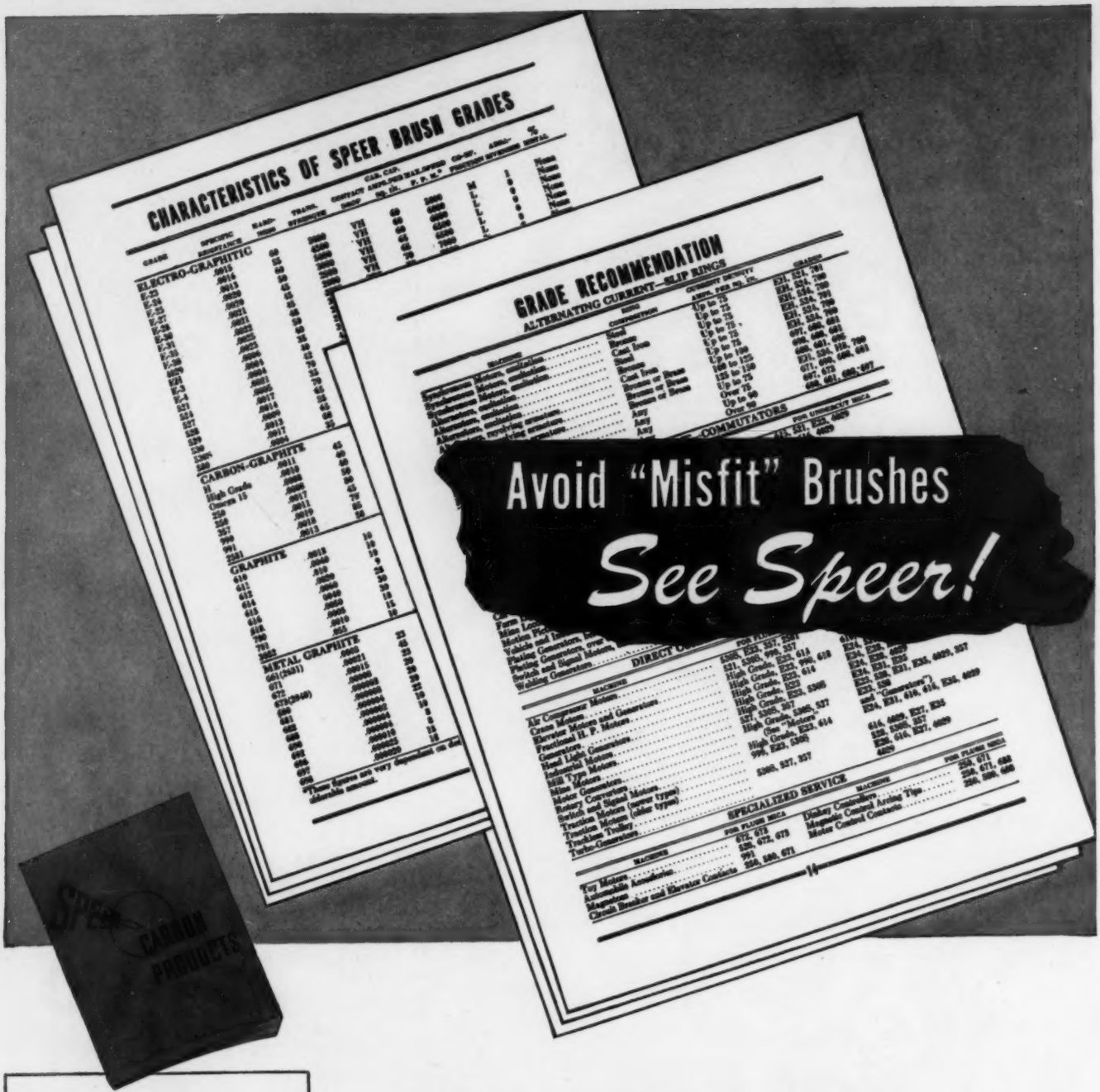
COST LESS
. . . lowest cost per foot per amp. of any bus conductor.

FOUR TYPES
. . . flat bars, angles, channels, tubes. All standard sizes.



ALCOA FIRST IN ALUMINUM

IN EVERY COMMERCIAL FORM



MORE ANSWERS
in this book. Get it!

This catalog, SPEER CARBON PRODUCTS, gives detailed information on brush characteristics, includes Speer Brush Data Sheets. It answers your questions on brush selections, helps you find the right brush for your motors or generators.

Each grade in the wide range of Speer graphite, carbon-graphite, electro-graphite and metal-graphite brushes has proved highly efficient in meeting specific commutating problems. Each grade has distinctive physical and electrical characteristics which make it the best choice for certain operating conditions.

Selecting the proper brush grade—the right brush with the right combination of essential properties—for peak commutating performance is a specialty at Speer—and has been for nearly 50 years . . . a specialty that many designers, builders and users of commutating machines rely on to save time, trouble and expense on brush problems. Perhaps Speer can help you.

2966

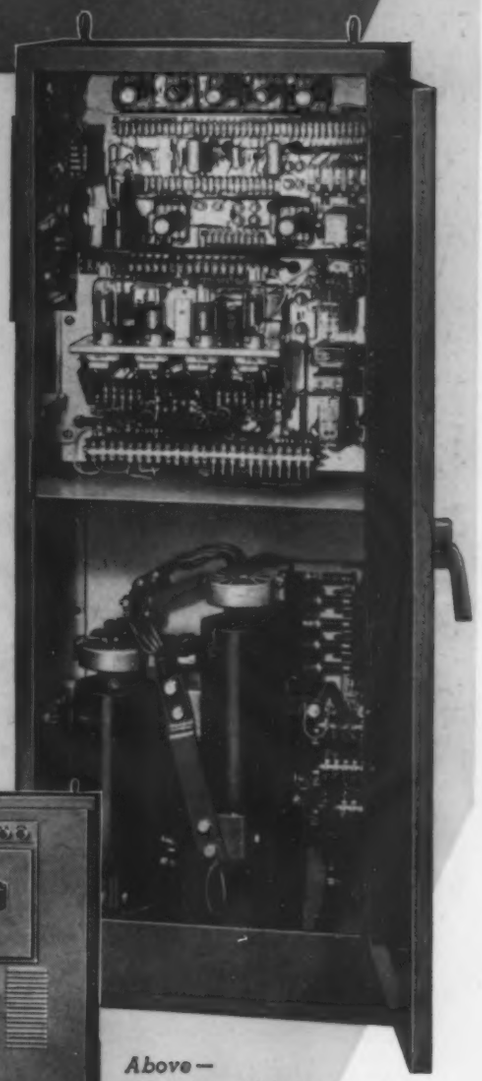
Speer
CARBON COMPANY
ST. MARYS, PENNA.

brushes • contacts • welding electrodes • graphite anodes • rheostat discs • packing rings • carbon parts

CHICAGO • CLEVELAND • DETROIT • MILWAUKEE • NEW YORK • PITTSBURGH

NOW Electronic WELDER CONTROL designed to INDUSTRIAL STANDARDS

***NEW** Square D Class 8993 combination controllers for resistance welders incorporate, in one enclosure, electronic contactor, heat control, synchronous-precision weld timer, and sequence panel. They provide accurate time and current measure recommended for welding non-ferrous metals, stainless steels, small parts and other critical jobs.*



IMPORTANT NEW CONSTRUCTION FEATURES

- All terminal connections and tie points are made accessible by opening main door and swinging out weld time panel.
- Simple tools—screw-driver and pliers—can be used to replace components. Number of soldered connections is minimized.
- Functional sub-panels (contactor, heat control, timing, and sequencing) have separable connectors—may be quickly removed or replaced.
- Designed for mounting on side of machine or for wall mounting.

IMPORTANT NEW CIRCUIT FEATURES

- New separate excitation circuit for ignitrons makes firing independent of voltage or load current. Firing pulses have consistent amplitude and duration for all heat control settings from 20% to 100% current.
- Synchronous-precision weld timing circuit operates on new differential discharge principle. Voltage changes before or during the weld have no effect on timing accuracy.
- All-electronic circuit has no sequencing relays and is of simplified design. For maximum safety, air valve is energized by a magnetic contactor. A no-weld relay disconnects firing tube anodes only in response to no-weld and water-flow switches, and warm-up timer.
- Coupling transformers isolate functional sections of circuit for maximum safety and efficiency. Initiating, no-weld, and pressure switch circuits are 110 volts.

Above—
All circuit terminals and tie points accessible by opening main door and swinging out sequence panel.

Left—
Controller can be arranged either for side of machine mounting or wall mounting.

Write for Bulletin 208 • Square D Company • 4041 N. Richards St. • Milwaukee 12, Wisconsin

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D CANADA, LTD., TORONTO, ONTARIO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

'Surface' OIL-FIRED

Modern, One-Way Fired, Recuperative Type featuring control of temperature and combustion to give all the engineering and operating advantages offered in the popular 'Surface' One-Way Gas-Fired Pits.

'Surface' engineered and built its first oil-fired pits in 1934. Since that date there has been a total of 80 'Surface' oil, oil-gas, or oil-tar fired pits installed in plants of leading steel producers.

These 'Surface' Oil-Fired Pits have lowered operating costs . . . solved seasonal fuel problems, or partial capacity operation, and made fuel storage possible, where such problems were of great importance to the operator.

Again, 'Surface' has proved ability to meet industry's needs by providing equipment to accomplish a desired result. This flexibility in equipment application has simplified operation and lowered production costs for operators.

In addition to one-way fired soaking pits, 'Surface' has a complete line of heating and heat treating equipment including slab heating furnaces—billet reheating furnaces—continuous heat treating furnaces for plate—continuous strip annealers and normalizers—pit-type convection furnaces for annealing rod, wire or strip in coils, high alloy rod and bar, atmosphere annealing furnaces of car-bottom lift-cover type—bright annealing and normalizing furnaces for tubing—stress relief furnaces—wire patenting furnaces—annealing covers, and the foremost equipment in prepared atmosphere generators for practically every heat treating operation.

It will pay you to discuss your heating and heat treating problems with a 'Surface' engineer.

Above: A most rece... 'Surface' Oil-Gas O... Way Fired Soaking ... installation at Cia Fun... dorede Fierro, Monter... Mexico.

'Surface'

SURFACE COMBUSTION CORPORATION

TOLEDO 1, OHIO

SOAKING PITS

6
REGENERATIVE TYPE PITS WITH TOTAL CAPACITY OF
36 INGOTS
GAS-FIRED *ONLY*

6
'SURFACE' ONE-WAY FIRED PITS WITH TOTAL CAPACITY OF
84 INGOTS
OIL-GAS FIRED

'Surface' Increased Installed Capacity 133⅓%

← In the foreground the above photograph, the battery of six 'Surface' One-Way Oil-Gas Fired Soaking Pits has a total installed capacity, under the service of the pit crane, of 84 — 22 in. x 24 in. ingots. In the background of the same photograph is shown six regenerative type pits with a total installed capacity of only 36 ingots. Therefore, in the same size area, between the building columns, 'Surface' has provided an *increased installed capacity of 48 ingots.*

fast, new ingot-buggy drive ...eliminates heavy contactors ...uses fewer collector rails ...costs less to maintain

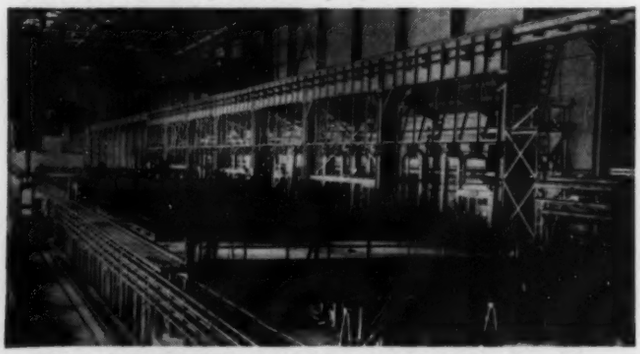
engineered drive assures fast delivery of ingot to mill despite increased buggy travel and higher rolling speeds

As an important factor in boosting production, General Electric's new ingot-buggy drive has caught the interest of many mill operators. The past decade saw ingot size, buggy travel distance, and rolling speeds increase to a point where the conventional buggy drive had become highly inadequate. Power losses during acceleration and deceleration were excessive. Braking difficulties were experienced and the cost of maintaining a large number of control contactors and collector rails was high.

Initial use of the new General Electric ingot-buggy drive proved it has overcome these disadvantages. Built around an adjustable-voltage amplidyne control system, the new drive gives the operator these advantages:

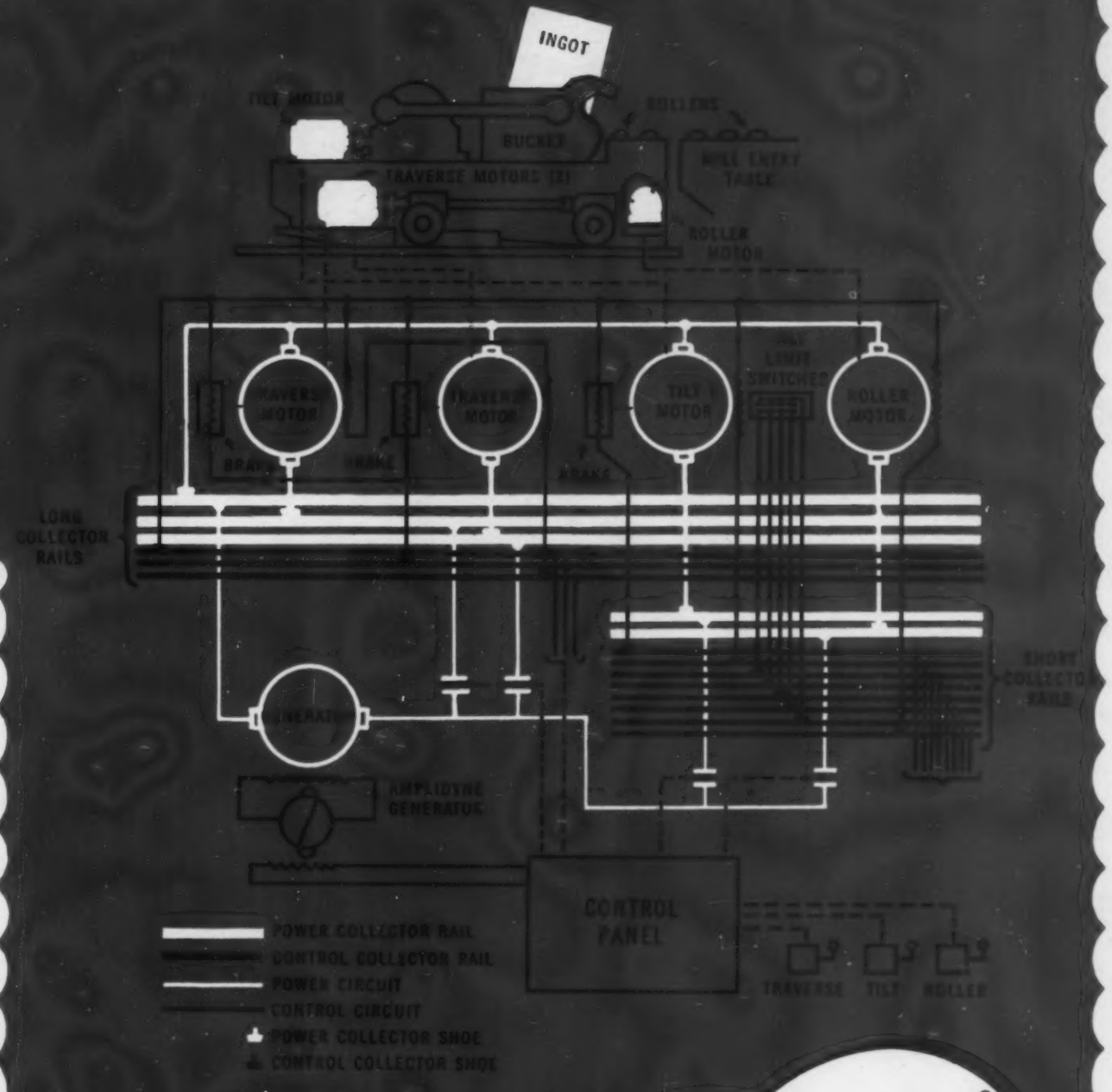
- ***Motor torque is applied smoothly and uniformly thereby permitting higher rates of acceleration and deceleration.***
- ***Operating speeds are higher because of the ability of mill-type motors to operate on double armature voltage.***
- ***The number of collector rails and control devices is reduced.***
- ***Mechanical wear and tear is reduced; brakes are used only for holding and emergency stopping.***
- ***Assures minimum mechanical and electrical maintenance.***

This new drive is a good example of the ability of General Electric to meet industry's demand for higher speed and more accurate control in electric drives. Moreover, when the operator brings his drive problems to General Electric, he avoids considerable trouble and expense because the task of co-ordinating the components of a modern electric drive is assumed by a General Electric application engineer. From preliminary engineering to final checkup after installation, the operator can draw on the experience and counsel of a trained specialist. Whether you are considering the installation of a new drive or the modernization of an old drive, it will pay you to talk to the General Electric steel mill engineer in your locality. No obligation, of course. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*



Shown here are typical soaking pits in a rolling mill with an ingot crane transferring an ingot to the buggy at the far left.

GENERAL ELECTRIC

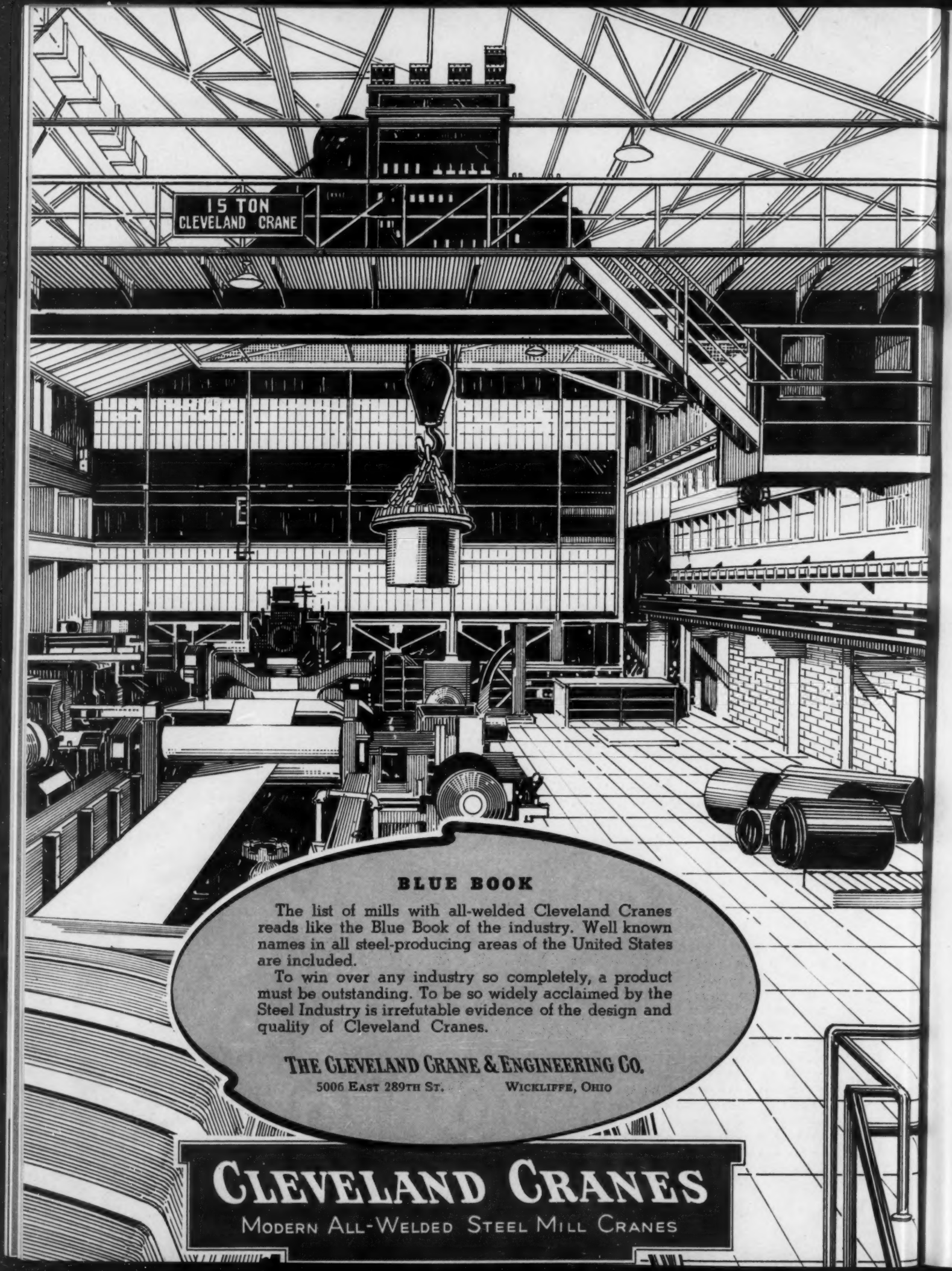


PLAN OF A TYPICAL G-E INGOT-BUGGY DRIVE

All control and power circuits are connected to the buggy by collector rails with collector shoes. Control signals are fed into a General Electric amplidyne. The latter functions as a regulating exciter. It amplifies the control signal and uses it to vary the excitation of the main generator which supplies power to the two traverse motors, the tilt motor, or the roller motor, as selected by the operator. The motors slow down or speed up as armature voltage is varied by decreasing or increasing excitation of the main generator. During regenerative braking, full braking torque can be developed at the lowest speeds by this same control.

another example of

drive engineering at work!



BLUE BOOK

The list of mills with all-welded Cleveland Cranes reads like the Blue Book of the industry. Well known names in all steel-producing areas of the United States are included.

To win over any industry so completely, a product must be outstanding. To be so widely acclaimed by the Steel Industry is irrefutable evidence of the design and quality of Cleveland Cranes.

THE CLEVELAND CRANE & ENGINEERING CO.

5006 EAST 289TH ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

A recent survey of the scrap situation indicates that, although scrap is desperately short, the steel industry should be able to squeeze through the coming winter without curtailment from lack of scrap.

Scrap prices have hit an all-time high at about $42 per ton.

▲

THE shortage of steel scrap has brought forth many suggestions that war-time scrap in Europe be gathered up and returned to the United States. Now comes the idea, in conjunction with the Marshall plan, that the United States export some 8,000,000 tons of scrap to Europe during the next four years. This is not a great amount, percentage-wise, of our scrap consumption, but it would certainly aggravate the prevailing shortage. Perhaps an intensive scrap collection drive should be instituted in Europe.

▲

NOW that election is over and the politicians have stopped working their gums, they can resume gumming the works.

▲

ADD steel expansion items:

United States Steel Corporation. Over $50,000,000 appropriated in 1947 for plant improvements and expansion in the Chicago district. This brings the company's total expenditures for these purposes to about $300,000,000 since 1941.

Republic Steel Corporation. Commitments of $108,550,000 since V-J day; 17 per cent more production now than the company was capable of in 1939.

National Steel Corporation. Spending $100,000,000 between war end and end of 1948. Capacity to be increased 800,000 tons of ingots per year.

Ford Motor Company. Spending $18,000,000 for a new blast furnace and other facilities.

Bethlehem Pacific Coast Steel Corporation. Spending $15,500,000 for new electric furnaces, blooming mill, bar and rod mill, and wire mill.

Sharon Steel Corporation. Installing new electric furnace and opening up coal and beehive coke facilities.

Jones and Laughlin Steel Corporation. A $100,000,000 program covering all departments of the corporation. This program will add 150,000 tons per year to the corporation's ingot capacity and will improve quality and efficiency.

AVERAGE factory pay is now somewhat over $49 per week, compared with an average of $23.86 in 1939, but after adjusting for tax deductions and higher living costs, Bureau of Labor Statistics experts estimate the present wage is worth only $26 in terms of the 1939 dollar. That's inflation — and we don't mean the kind that, when your tire blows out, you have none of.

▲

What with prices going up and up, it's getting so that no one can afford to work for what he's worth.

▲

CARBON bottoms for blast furnaces received orchids at the recent joint meeting of the Blast Furnace and Coke Association of the Chicago District and the Eastern States Blast Furnace and Coke Oven Association at Cleveland. All reports were very favorable.

One steel company is now planning to carry a carbon lining up past the tuyeres.

▲

ONE consolation, of those two certainties of life, death and taxes, only one gets worse with each session of our legislative bodies.

▲

THE production rate of open hearth furnaces is doubled by the use of a blown metal charge instead of the usual scrap and hot metal charge, according to a survey made by the American Iron and Steel Institute. While furnaces produced 14 – 26 tons per hour with the conventional charge, production rates ranging 36 – 50 tons per hour prevail in furnaces operating on a blown metal charge.

▲

THE value of being level-headed depends upon how high or low the level is.

▲

EMPLOYEES of Richard Thomas and Baldwins, Ltd., Swansea, Wales, listened to an address by proxy from their board chairman, E. H. Lever. Mr. Lever, visiting the United States, made a wire recording of his speech. The recording was flown to Britain and was run off at an employee's meeting.

Mr. Lever suggested a slogan: "Prosperity through Production," and outlined a five-point program for its accomplishment:

1. Determination that the country and the industry shall prosper.
2. An understanding of the part each individual plays, and the responsibilities involved.
3. Greater opportunity for mutual consultation.
4. Determination to do a fair day's work for a fair day's pay, and to eliminate waste.
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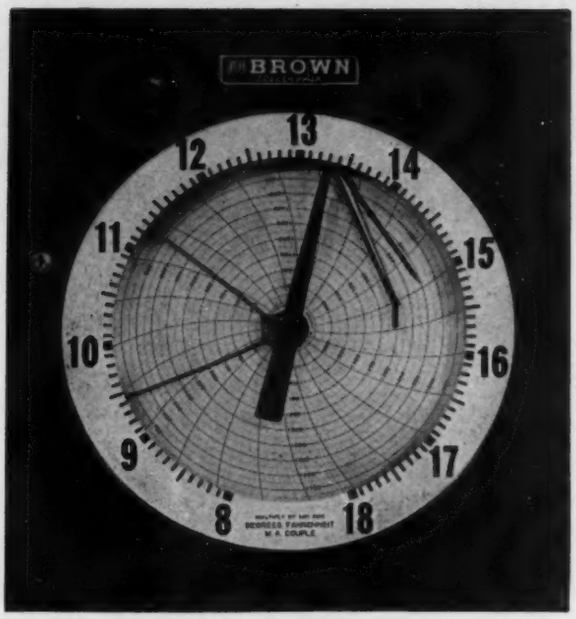

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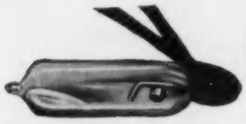

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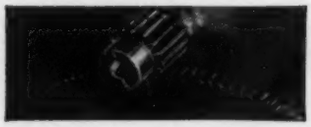

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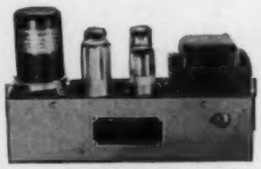

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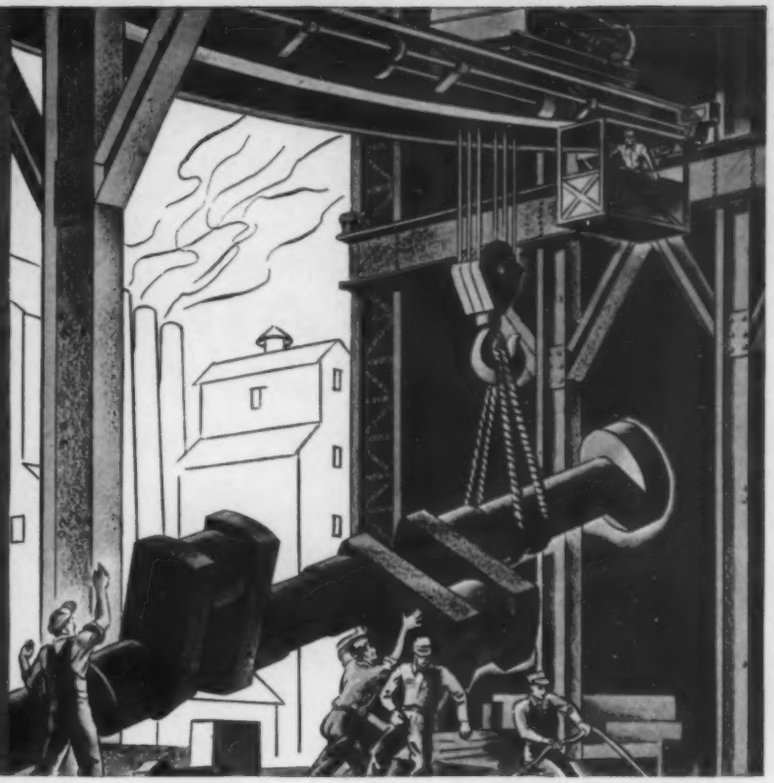

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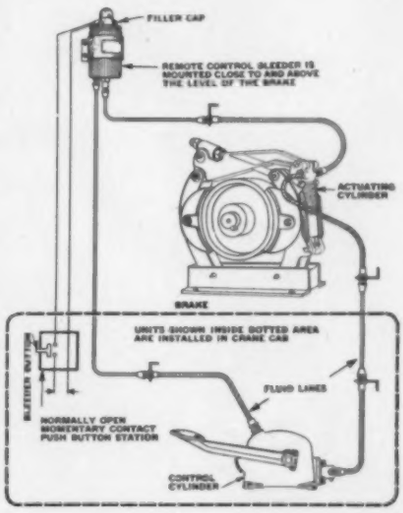
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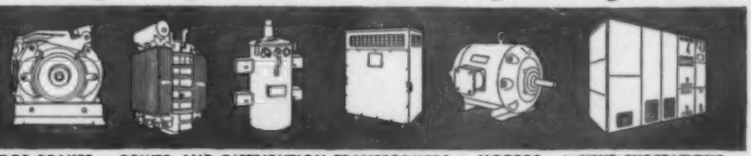

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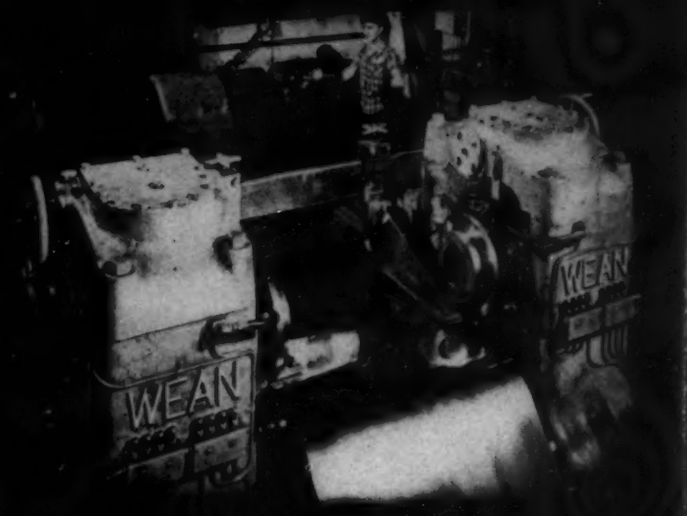

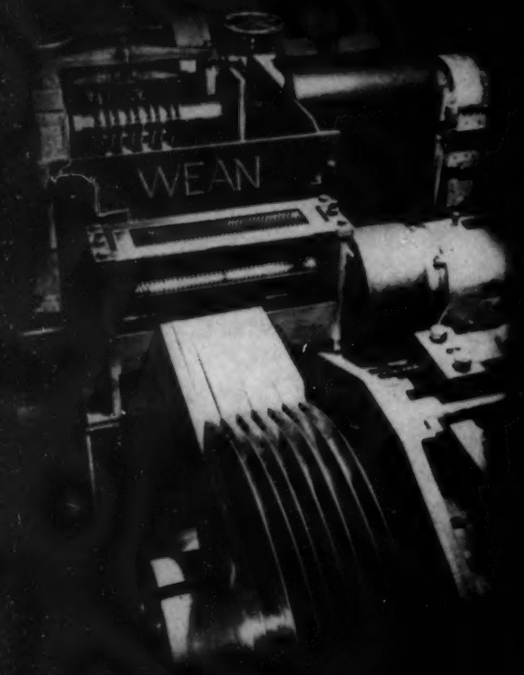

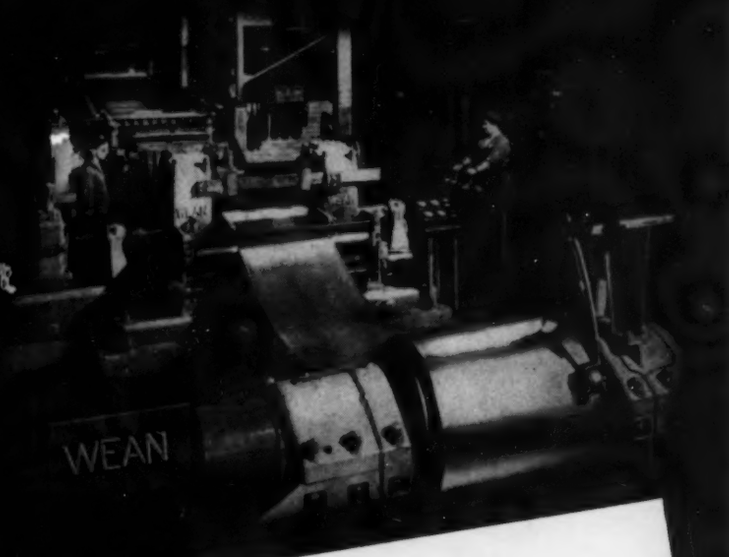

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Oxygen - Accelerated Combustion

IN OPEN HEARTH FURNACES

. . . . the dual use of oxygen for accelerating combustion and burning elements in the bath opens new vistas in open hearth steel making practice . . . .

By E. T. W. BAILEY
Combustion Engineer
Steel Company of Canada, Ltd.
Hamilton, Ontario, Canada

▲ IN 1774 Priestly discovered oxygen. During our school years all of us learned how oxygen was produced from air or water and how it supported combustion in a very vigorous fashion. Most of us are familiar with its principal present day uses for welding, cutting and scarfing operations. Technical writers have speculated for years upon its use in various processes and especially those requiring the combustion of fuels. The high cost to produce oxygen has heretofore prevented its being applied to processes requiring relatively large volumes.

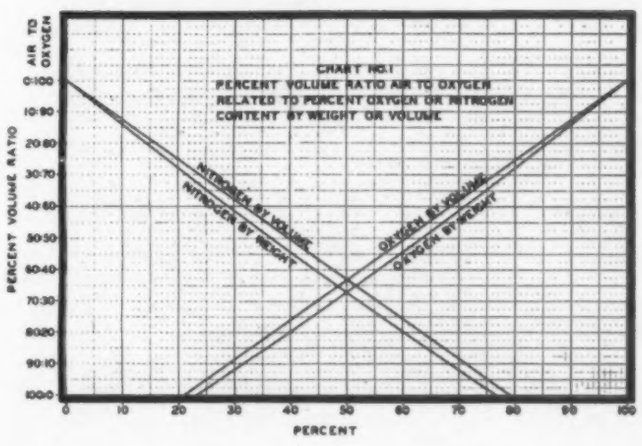
About sixteen years ago Frankl suggested the use of regenerators to replace the heat exchangers generally employed in the process of manufacturing oxygen from the air. These regenerators improved efficiency, were simpler to construct, and were capable of removing moisture and carbon dioxide from the air. As a result of this latter feature, scrubbing and caustic towers could be eliminated. The large reduction in pressure drop across regenerators allowed the use of turbo type compressing and expanding units in the place of the rather massive reciprocating engines. It was found that a product gas containing from 95 to 98 per cent oxygen could be produced. The high purity oxygen (99.5 per cent) needed for welding, cutting and scarfing could not be made for the reason that the outgoing oxygen picked up some trapped air as it passed through the reversing regenerators. This difficulty made Frankl's scheme unsuitable when the oxygen is required for torch work. It is, however, of no practical significance when it is to be applied in large volumes to combustion, metallurgical or many chemical processes.

High capacity low cost oxygen producing plants have been built principally in Germany, France and Russia. Individual units of these plants produce 2.8 million cubic feet per day. Other plants are being either built or considered for Holland, United States and Canada.

During the last few years the application of oxygen to large industrial furnaces has been made in a few places. These large scale experiments were chiefly confined to gas producers, bessemer converters and blast furnaces. Some tests were carried out by G. Bulle who employed oxygen enriched air for burning lean fuels such as blast furnace gas in a small open hearth furnace. The tests were on a small scale and the results were said to be encouraging. Russian engineers have reportedly experimented with oxygen enrichment especially in blast furnaces.

There does not seem to be very much information in the literature concerning the large scale use of oxygen. This is undoubtedly largely due to its not being made generally available at a cost that would allow such test applications. Where it has been made available, engineers have thought in terms of oxygen enrichment of air in processes which depend solely upon the combustion of fuels for heating and melting. When oxygen is added to a relatively large volume of air to be used for burning a fuel, the practice is commonly termed "oxygen enrichment." For some applications this method of introducing oxygen may be suitable, but in the case of

Figure 1 — This chart enables one to quickly determine how much total oxygen or nitrogen is present in a mixture of air and oxygen.



Presented before AISE Buffalo District Section Meeting, April 8, 1947

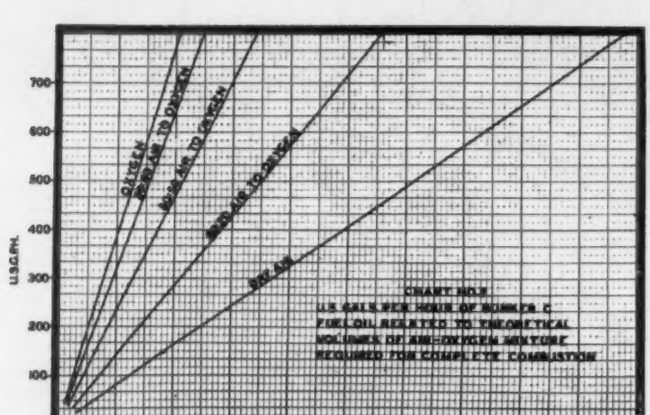

U.S.G.P.H.
C.F.M. X 1000
CHART NO. 2
U.S. GALS. PER HOUR OF BUNKER C FUEL OIL RELATED TO THEORETICAL VOLUMES OF AIR-OXYGEN MIXTURE REQUIRED FOR COMPLETE COMBUSTION

Figure 2 — The amount of air-oxygen mixtures to theoretically burn Bunker C oil is given in this chart.

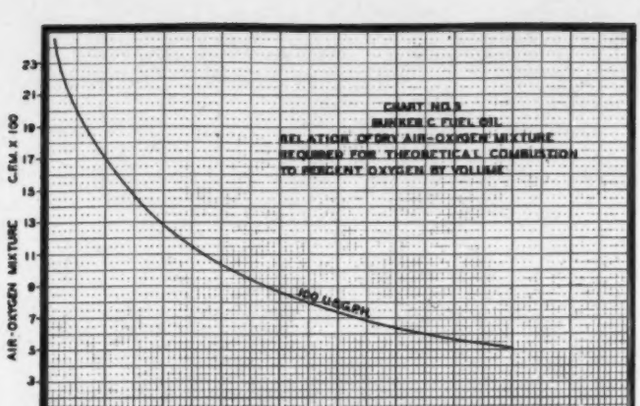

C.F.M. X 100
AIR-OXYGEN MIXTURE
CHART NO. 3
BUNKER C FUEL OIL
RELATION OF DRY AIR-OXYGEN MIXTURE REQUIRED FOR THEORETICAL COMBUSTION TO PERCENT OXYGEN BY VOLUME
100 U.S.G.P.H.
PERCENT OXYGEN BY VOLUME

Figure 3 — The quantity of various air-oxygen mixtures required to burn 100 gphr of Bunker C oil is given.

open hearth furnaces, where melting scrap requires short, sharp flames, the results show only moderate improvement. The whole furnace receives an undesired amount of heat and localized control is not substantially improved.

As against the plan of using oxygen to enrich the air normally supplied for combustion reactions is the recently conceived scheme of having oxygen directly contact the fuel. The remaining oxygen required to complete combustion is then supplied from air admitted into the furnace in the normal manner. This process or scheme is being called oxygen accelerated combustion. It has produced results that at first glance appear out of proportion to what could be expected. The probable reasons for these exceptional results and their implications is the subject of this paper.

The Hamilton plant of the Canadian Liquid Air Company, Limited, supplies the Hamilton works of the Steel Company of Canada, Limited, with 99.5 per cent oxygen at 160 psi gage by means of an interconnecting pipe system. This oxygen is normally used for welding, cutting and scarfing operations. On learning that low cost oxygen could technically be furnished in large volumes at around 95 per cent purity, it was decided to store a volume of the 99.5 per cent oxygen which could be used on week-ends for the purpose of conducting a few large scale experiments. To this end plans were made and a 180-ton open hearth furnace was selected, the oxygen volume requirements of which appeared to be within the capacity of the facilities available. The scheme of enriching the air by admitting oxygen into the checkers was abandoned at the start in favor of introducing the oxygen adjacent to the incoming fuel and thereby accelerate combustion. In general, the considerations leading to the adoption of the scheme were as follows:

Fuel ignition — Heavy fuel oils are more difficult to burn at desired rates when the furnace temperature is appreciably below normal. This is true even though the correct amount of combustion air is supplied. It was reasoned that the introduction of oxygen adjacent to the atomized fuel oil as it entered the furnace would entirely overcome this handicap. Subsequent tests proved this supposition was correct and ignition was advanced beyond anything observed before even when furnace temperatures were at their highest values. This feature is considered to be of paramount importance where short hot flames are required.

Flame development — Once having established early and active ignition the next consideration is flame development. Under normal conditions the ratio of port area used to admit air to that admitting oil is something in the order of 10,000:1. The atomized oil then has to contact a large volume of air and at the same time be expected to develop a high release of heat in as short a space as possible. It is really remarkable that results are as good as they are when consideration is given to the physical handicaps imposed on the entering fuel oil and air which mitigate against their early and complete chemical union. Combustion tests showed that not only could ignition be instantly and completely established but that combustion could be accelerated to an unusual degree. This degree of acceleration appeared to be out of proportion to the small amount of oxygen admitted when compared to the total oxygen required for complete combustion.

It has been said that "pre-mixing and burning of fuel with air to get a maximum flame temperature and flame location in a furnace is the most desirable approach to fuel economy." The introduction of oxygen along with the fuel at the point of entry can be compared to the discovery of a new tool whereby a means is now at hand for lengthening or shortening a flame, increasing or decreasing its calorific output, and directing its travel all within limits much greater than those heretofore in general use.

It has been suggested, with considerable justification, that the mechanism of the combustion of gaseous hydrocarbons from fuels follows the hydroxylation theory deduced from the researches of Bone and his collaborators. Briefly, this theory maintains that there is a combination of the hydrocarbon with oxygen preliminary to final combustion. Alcohols and aldehydes are formed previous to burning to carbon monoxide, carbon dioxide or water. This holds true at all temperatures. These interactions of the hydrocarbon with oxygen form unstable oxygenated or hydroxylated compound. Enough oxygen present prevents the formation of soot in the

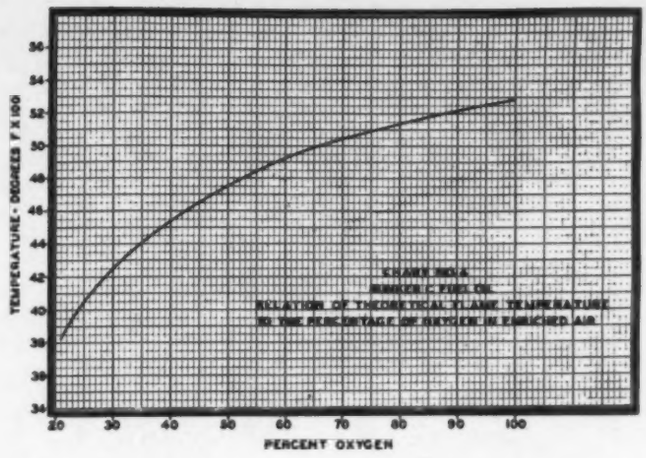


Figure 4 — This chart relates the theoretical flame temperature with various percentages of oxygen.

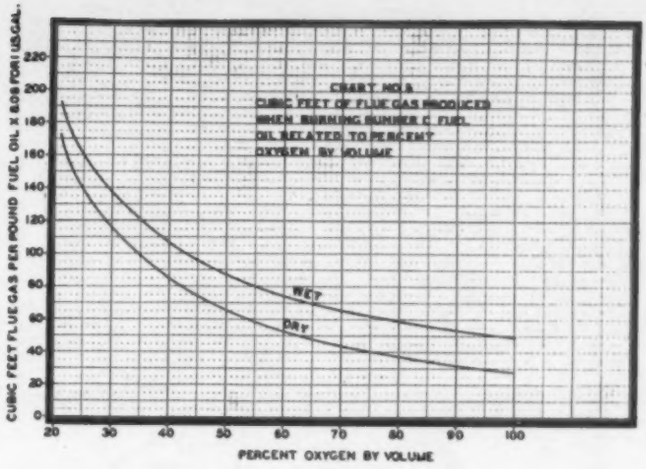

CUBIC FEET FLUE GAS PER POUND FUEL OIL X 808 FOR U.S.GAL.
CHART NO. 5
CUBIC FEET OF FLUE GAS PRODUCED WHEN BURNING NUMBER C FUEL OIL RELATED TO PERCENT OXYGEN BY VOLUME
WET
DRY
PERCENT OXYGEN BY VOLUME

Figure 5 — Volume of flue gas produced by burning Bunker C oil.

flame and the combustion can be said to be accelerated.

There appears to be no obstacle in the way of having the same burner provide highly luminous flames at such time as melting is complete and it is desired to increase radiation to the bath. The flexibility thus offered makes the hitherto limited open hearth burner more universal in its application.

Rate of fuel input — The open hearth furnace has often been justly criticized for having many features of poor design. But, when one considers its triple function of heating, melting and refining, it is, after all, a fairly good compromise. At least it works, and it has outstripped all competitors to date. The variation in the temperature of the charge all the way from below zero scrap to molten steel approaching the 3000 F figure is not encountered in many other processes. In such a case it becomes very desirable to increase the rate of heat input to a furnace especially after a portion of the scrap charge has been made. This however is the time when it is especially difficult to burn the desired amount of fuel. Cold furnace walls and scrap interfere with ignition and flame development. The scrap often mechanically deflects flames and has the effect of reducing the furnace volume. The net result is that less, not more, than the desired amount of fuel can be efficiently burnt during this period of a heat.

When oxygen accelerated combustion is used, many furnaces are enabled to completely burn fuel oil at a rate in excess of that normally employed. This augmented rate of calorific input cannot but help increase the rapidity with which the scrap heats and melts. Air temperatures remain slightly higher during the melting period and more uniform throughout the duration of the heat.

Refractories — Many remarks concerning the effect of oxygen accelerated combustion upon refractories can at present writing be classed as speculation. However, a sufficient number of tests have been conducted to substantiate the claim that given reasonable supervision, especially toward the end of the meltdown period, no undue ill effects are discernible. Previously, this item seems to have given considerable concern to writers and experimenters. It was reasoned, however, that so long as there remained any substantial amount of unmelted scrap in the furnace there would be little danger to refractories from the hotter flames. The capacity of the unmelted scrap for absorbing heat is well beyond the rate of heat that could be released even at fuel rates 60 per cent above those normally employed. There seems to be good reasons for taking the optimistic view that brick costs per ton of ingots will be sharply reduced. As yet there is little evidence to indicate what the campaign life of a furnace will be. Expectations are that it should not be materially shorter than at present.

In another part of this paper, mention will be made of an oxygen accelerated combustion test made in an open hearth furnace having complete roof and downtakes constructed with basic brick.

The practice of lancing baths with oxygen has proven a little rough on silica refractories. There is reason to believe that basic construction of roofs and ends may have come along at the right time to provide an answer to this problem.

Reference charts — A number of reference charts have been prepared which have been found to be of assistance when studying the application of oxygen to combustion in a general way. These charts relate to fuel oil but companion charts can be prepared for any other type of fuel.

Figure 1 is useful where it is desired to quickly relate per cent oxygen or nitrogen by volume or weight to a mixture of air and oxygen in a given per cent volume ratio.

Figure 2 shows the volume of air or air-oxygen mixes in ratios of 80:20; 50:50; 20:80; and pure oxygen required to completely burn bunker C fuel oil at various rates of flow.

It is interesting to note that when burning 500 U. S. gphr of oil the volume of air required is 12,200 cfm whereas when 80:20 air-oxygen mixture is used the volume required is 7000 cfm, a reduction of 43 per cent. On the other hand in the case of using a mixture of 20:80 air to oxygen a volume of 3000 cfm is required. This compares with a volume of 2600 cfm of pure oxygen, a reduction in volume of 13 per cent. The rate of the percentage reduction of nitrogen is very rapid when oxygen is added to air and becomes very slow as the state of pure oxygen is approached.

Figure 3 gives a curve which has proven useful in the

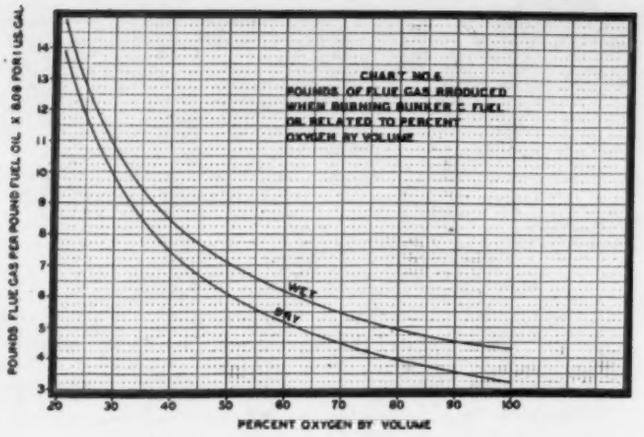


CHART NO.6
POUNDS OF FLUE GAS PRODUCED WHEN BURNING BUNKER C FUEL OIL RELATED TO PERCENT OXYGEN BY VOLUME
WET
DRY
POUNDS FLUE GAS PER POUND FUEL OIL X 8.08 FOR U.S. GAL.
PERCENT OXYGEN BY VOLUME

Figure 6 — Weight of flue gas produced by burning Bunker C oil.

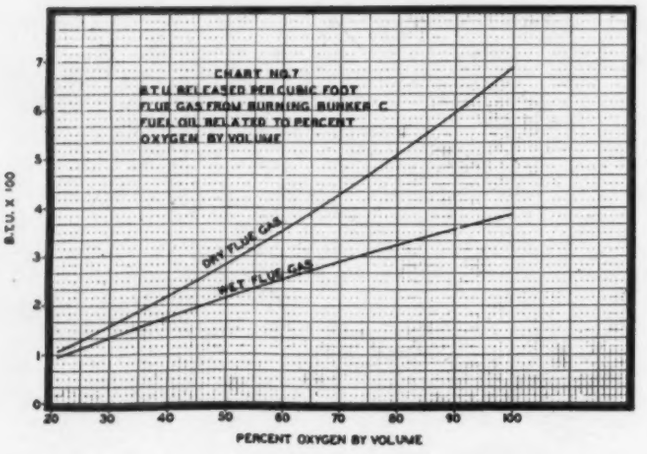


CHART NO.7
B.T.U. RELEASED PER CUBIC FOOT FLUE GAS FROM BURNING BUNKER C FUEL OIL RELATED TO PERCENT OXYGEN BY VOLUME
DRY FLUE GAS
WET FLUE GAS
B.T.U. X 100
PERCENT OXYGEN BY VOLUME

Figure 7 — Heat released per cubic foot flue gas.

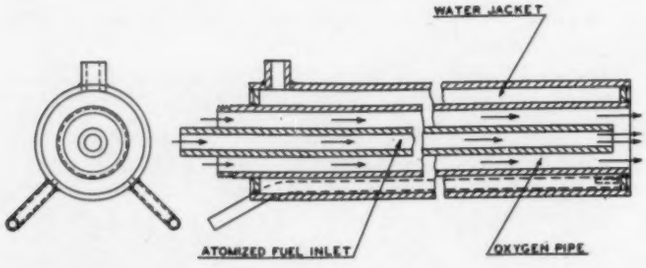


Figure 8 — Typical burner used for atomized fuels and oxygen.

field as it relates per cent oxygen by volume as contained in the air supplied to the air-oxygen mixture expressed in cubic feet per minute required to completely burn 100 U. S. gallons of oil per hour. This chart is used along with Figure 1 which first allows a per cent volume ratio of a mixture to be converted into per cent oxygen contained in that mixture.

The rapid reduction in air-oxygen volume required per 100 U. S. gphr of oil burnt as the per cent oxygen is uniformly increased over that contained in air should be noted.

Figure 4 shows a curve relating the theoretical flame temperature resulting from burning fuel oil to the percentage of oxygen in the air. The curve ascends rapidly for oxygen additions to air and flattens markedly as 100 per cent pure oxygen is approached. This characteristic helps to explain why small increases in oxygen supplied to a furnace can produce relatively larger increases in operating results.

Figures 5 and 6 indicate the volume and weight respectively of flue gas produced measured on both wet and dry basis when burning one pound of bunker C fuel oil using air containing varying percentages of oxygen. The steep slope of these curves towards the 20 per cent oxygen side of the chart should be observed.

Figure 7 is interesting as the curves show an almost uniform rate of increase in the Btu released per cubic foot of flue gas resulting from the combustion of bunker C oil using air containing various percentages of oxygen by volume.

Like many other steps that have been taken to improve the art of steelmaking, that of applying oxygen accelerated combustion appears reasonably simple once it has been accomplished. About the only additional equipment required at each oil fired furnace is:

1. A rate of flow valve preferably remotely controlled.
2. A recording integrating flow meter.
3. Two reversing valves that will function on the same time cycle as the steam reversing valves.
4. Two burners having an annular space around the atomized oil burner pipes.
5. Means to check spent gases leaving the furnace so that their oxygen content can be maintained at a normal figure by readjustment of the air volume delivered from the checkers.

Several varieties of burners having all sorts of combinations of the relationships of their parts to one another have been tried at different plants. So far as can be learned these changes have not resulted in any great improvement over the original design. It has always been difficult to assess the true worth of any new practice or device applied on an open hearth furnace. There are many variables and few changes are drastic enough to say "this, and this alone, has produced the improvement." This is the situation where minor burner changes are made. A probable reason that no great performance improvements have been recorded as a result of burner changes is that the atomized oil creates a powerful vacuum as it leaves the burner pipe. The effect of this vacuum extends well back into the annular chamber conveying the oxygen. In one case a pressure of 63 psi gage existing in the oxygen line 75 feet ahead of the burner became a pressure of minus 34.5 inches water at the entrance to the annular space conveying oxygen into the furnace. The high velocity of the atomized oil jet emerging from the burner pipe pulls the oxygen into itself like a powerful magnet draws a bar of steel. For rapid and thorough mixing practically no other point in the fuel system offers more advantageous conditions and no minor changes will greatly lessen the vigorous mixing effect set up at this focal point.

The first tests using oxygen to accelerate combustion in an open hearth furnace were made by the author early in 1942. A ¼ in. diameter copper tube was inserted along with the regular burner pipe so that the two streams emerged into the furnace alongside one another. Only one end of the furnace was so equipped and more rapid scrap melting was noted even though a

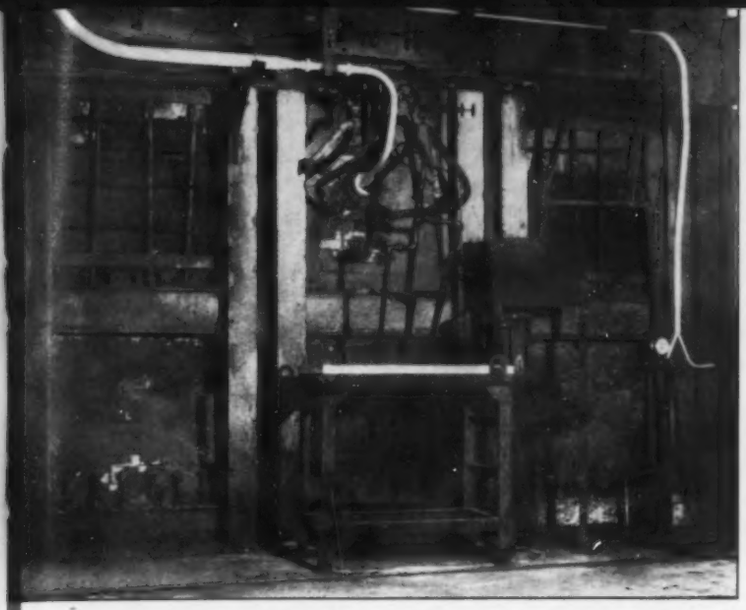


Figure 9 — Oxygen piping is shown in white on the end of the furnace. Branch line to right is for lancing.

Figure 10 — This flame results from burning 370 U. S. gphr of oil with air.

relatively small amount of oxygen could be introduced in this manner.

The next test, and the first of any real importance, was made on March 10, 1946 and consisted of admitting a flow of approximately 600 cfm of oxygen 3 in. above the atomized fuel oil as it entered the furnace. This was a preliminary test and no special data was collected. It provided indications on which items data should be recorded in order to aid the planning of future experiments and studies. The three observations made were: rapid ignition; ability of furnace to burn higher rates of fuel, and speedier melting of the scrap charge.

In the tabulation of test results, Table I, heats No. 2, 3 and 4 were very much alike except for differences in oxygen flows. In all cases the heats melted "hard" and adjustments had to be undertaken which lengthened the time beyond that required had they "come on the nose."

Test heat No. 6 which is being used as a standard for this comparison was produced by making available at

TABLE I

Tabulation of Test Results

Item	Test number				
	2	3	4	5	6
1. Total metallic charge — pounds	396,065	396,430	415,165	389,085	399,470
2. Hot metal charge — per cent	41.4	41.9	43.5	37.8	41.6
3. Charging time — hours-minutes	2-23	2-45	2-22	1-47	3-55
4. Elapsed time to hot metal addition — hours-minutes	3-04	3-18	3-09	3-22	5-20
5. Total time required for heat — hours-minutes	9-10	8-10	9-05	7-22	11-10
6. Tons produced	183.60	179.10	188.95	163.30	174.95
7. Yield per cent	92.7	90.4	91.0	84.0	87.6
8. Tons per hour (charge to tap)	17.91	21.90	20.72	22.07	15.67
9. Million Btu per net ton	2,908	2,939	3,486	3,301	4,346
10. U. S. gal oil per net ton	19.28	19.49	23.11	21.86	28.80
11. Nominal rate oxygen flow — cfm	600	700	800	1000	None
12. Experimental rate oil flow — U. S. gphr	500	500	600	700	500
13. Normal rate oil flow — U. S. gphr	370	370	370	500	370
14. Total oxygen used — M cu ft	124.9	155.7	165.5	190.8	None
15. Oxygen used — cu ft per net ton	680	870	876	1,168	None
16. Corresponding per cent oxygen content of air for theoretical combustion	25.7	26.7	26.4	26.9	21.0
17. Cu ft oxygen per pound of cold charge	0.538	0.676	0.706	0.788	.....
18. Rate of melting — pounds of cold scrap per hour taken to time of hot metal addition	75,600	69,800	74,500	71,900	43,700
19. Slag analysis — actual FeO	.....	9.8	6.0	9.0	11.5

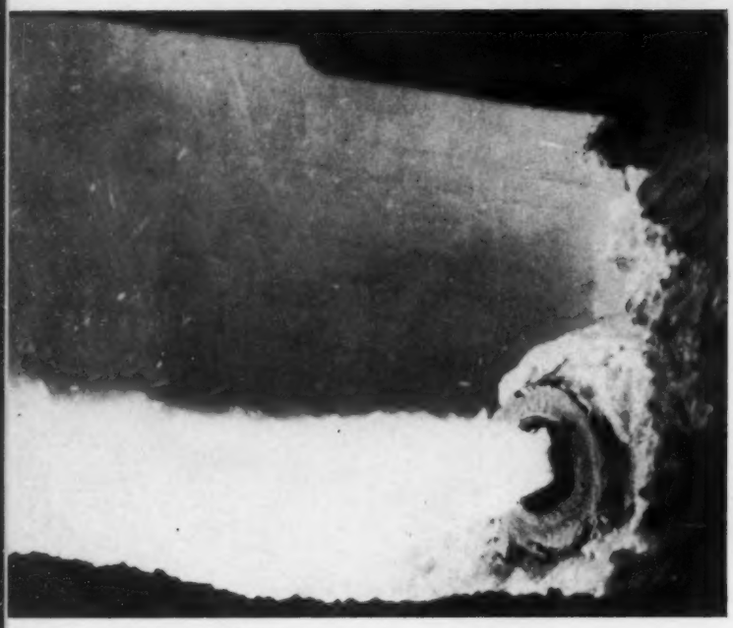
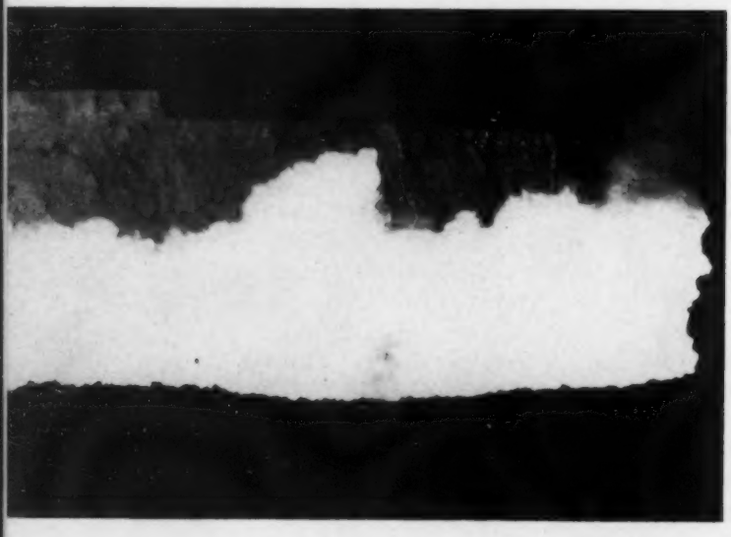


Figure 11 — Compare this flame from burning 500 U. S. gphr with 700 cfm accelerating oxygen with that in Figure 10.

Figure 12 — This is another view of the flame shown in Figure 11 from the door nearest the burner.

Figure 13 — View of flame of Figure 11 from the second door from the burner.



the furnace all materials when required. The operators were asked to do everything they could to reduce the time required to make a heat with the facilities at their disposal.

In order to assess and measure test results it becomes necessary to adopt a standard which can be used as a yardstick. In this case it is difficult to choose true average figures to represent a base heat. Everyone who knows of the many factors which may alter the time required to make a specific heat of steel in an open hearth furnace will understand this problem. The comparison made herewith is arbitrary and is only as valid as one in which any four heats are compared with a fifth heat having similar charging and other basic characteristics.

The average production rate expressed in net tons per hour for heats 2, 3, 4 and 5 was 31 per cent greater than heat No. 6.

The average fuel requirement expressed in thousands of Btu per net ton for heats 2, 3, 4 and 5 was 27 per cent less than heat No. 6. This reduction is greater than what normally could be expected as the fuel to make No. 6 heat was excessive due to a tendency to crowd the furnace.

Test heat No. 5 was produced in a furnace having a suspended roof as well as ends composed of basic brick. It will be agreed that the input of approximately 700 U. S. gphr of oil is probably a record for a furnace tapping around 180 net tons and having a bath area of 535 square feet. In order to further assist the rapid merging of atomized oil and oxygen in a mechanical way and also to broaden the resulting flame, a helecoidal insert was placed in the burner pipe 6 inches from the exit end. The helecoidal insert consisted of a double twist auger having a diameter and pitch of $1\frac{1}{16}$ inches and a length to give two complete turns. This device imparted a vigorous whirling action to the atomized oil-steam mixture which emerged into the furnace as a spinning core of the incoming oxygen stream. The oxygen was being injected at the rate of 1000 cfm. The resulting flame was very intense, blue-white and dimensionally greater than normal. Considerable roar developed not unlike a practically continuous explosion. At times very rapid separate explosions were just discernible and gave audible indications of very high rates of energy release taking place. The test ran smoothly and the intense flame was consistently produced without incident. Everyone who stood around the furnace received a pronounced "sunburn." Some discomfort to eyes and skin was noticeable and lasted for several hours. This was clear evidence that ultraviolet light was being produced and at an intensity far greater than that normally experienced. Roof temperatures were allowed to reach 3200 F towards the end of the scrap melting period. This temperature could not have been allowed had the roof been of silica composition.

The bath was lanced with oxygen to reduce carbon with the object of combining the two uses of oxygen in an effort to have a test indication of the total heat time required. The heat had to be forced tapped, owing to bottom trouble, about twenty minutes ahead of the expected time. There are indications that, given reasonably good conditions, a heat of steel can be made in

close to seven hours using 60:40 scrap to hot metal charge ratio, oxygen accelerated combustion and bath lancing. Average times (charge to tap) will, however, probably be at least one hour longer.

Item No. 16 in Table I is interesting as it signifies what the corresponding oxygen content of air would be were it supplied to equal that used in the combination of ordinary air and oxygen for accelerated combustion. This per cent oxygen content ranged from 25.7 to 26.9 per cent in the case of the four tests listed. With ordinary air containing 21 per cent oxygen it can be seen that the oxygen additions to produce accelerated combustion are relatively small.

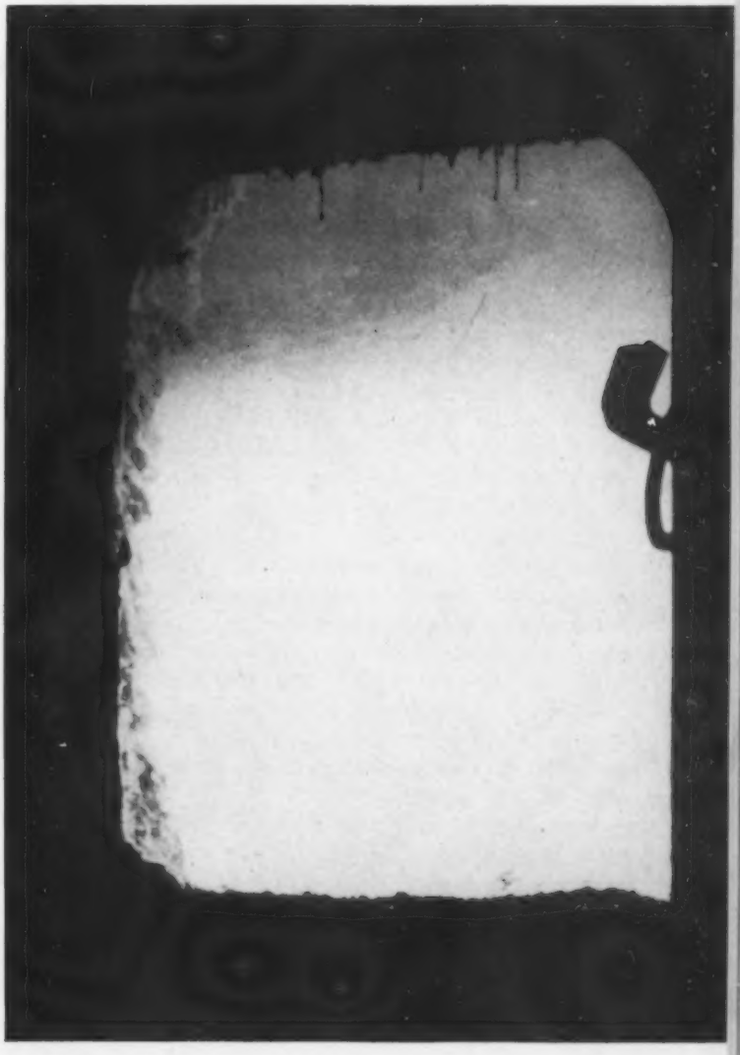
The reduction in melting time by at least 2½ hours is gratifying. Melting time may be further shortened when conditions include a plentiful supply of low cost oxygen thus permitting trials to determine the best combination of oil, air and oxygen flows as well as burner arrangement. The most effective method of charging scrap may be in stages whereby intervals are provided in order to allow exposure to the very hot flames. It has always been difficult to heat any material in small pieces when placed in a loose pile and scrap steel is no exception. Large doors held open for unduly long periods place a drag on the furnace.

It is considered that a sufficient number of tests have already been conducted to indicate the approximate gain that can be credited to oxygen accelerated combustion. Fears have been expressed that, lacking expert guidance, the benefits derived from oxygen accelerated combustion might become lost when placed in the hands of the operators. Just how this could happen without extreme measures being taken to deliberately sabotage the operation of the furnace is difficult to understand. Given approximately correct flows of oil, oxygen and air in a properly designed and installed burner, the gain due to oxygen acceleration is derived almost instantly and independently at the burner tip. Tests disclose that with outlet gases containing up to 200 per cent excess air melting time appeared to be only slightly longer. These fears should not be taken too seriously as good furnace operators will soon be able to equal if not surpass the efforts of the so-called experts when facilities for oxygen accelerated combustion are provided.

The dual use of oxygen for accelerating combustion and burning elements in the bath makes its application in the open hearth most interesting. It seems evident that, in shops using a very high ratio of hot metal in the charges, bath lancing may become the most important of the two uses. Most shops will be able to use oxygen for both purposes where facilities are such that materials can be moved to the proper place at the proper time. Other shops will require modernization of scrap and reagent storage, preparation and charging facilities to meet the increased production. The general feeling seems to prevail that given plenty of cheap oxygen combustion and open hearth men are ready to put it to effective use wherever the mechanics of supply are adequate.

Figure 14 — Flame resulting from burning 700 U. S. gphr oil with 1000 cfm accelerating oxygen. Burner tube has helecoidal insert.

Figure 15 — View of flame of Figure 14 through second door from burner.



ELECTRICAL EQUIPMENT FOR THE *Sendzimir Cold Strip Mill*

. . . . since the Sendzimir cold strip mill is usually designed to roll thin gages, precise electrical control is necessary in order that the required accuracy may be attained . . . .

By H. W. POOLE
Engineer, Steel Mill Division
General Electric Company
Schenectady, New York

▲ JUST about a year ago, Mr. Sendzimir presented a paper, "The Sendzimir Precision Cold Strip Mill," Association of Iron and Steel Engineers, Proc. 1946, on the design and use of the Sendzimir mill. At that time he pointed out that this was a precision mill for rolling a precision product. In order to reap the full advantages of such a mill, it is likewise necessary to equip it with the finest known electrical equipment, or precision electrical equipment.

It should be appreciated, however, that such electrical equipment is required because of the precision product being rolled and not necessarily because it is rolled on a Sendzimir mill. In fact, the problems encountered in applying electrical equipment to all reversing cold strip mills are similar, and the required quality and performance of the electrical equipment are largely functions of the product or products to be rolled.

All reversing cold strip mills present the general problems of speed control, tension control, acceleration and deceleration, etc. It is only the degree of accuracy with which these functions must be performed that varies from mill to mill. One unusual condition is sometimes encountered in connection with the Sendzimir mill, however, where very small work rolls or relatively small back-up rolls must be direct driven by d-c motors. The particular problem involved here of building large high-speed d-c motors is not normally encountered in dealing with conventional 4-high reversing mills. In general, however, the problems found in applying electrical equipment to all reversing cold strip mills are similar and the information presented in this paper will be generally universal.

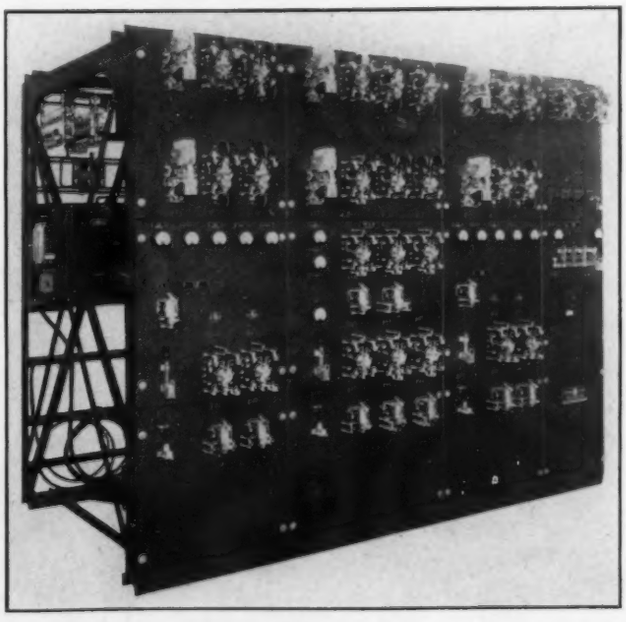
It is interesting to note that suitable electrical equipment must be furnished for quite a wide range of sizes of Sendzimir mills. Figure 1 shows the adjustable voltage control panel for a small mill. This mill rolls a maximum width of 6 inches at a maximum speed of 150 fpm. The main rolls are driven by a 10 hp d-c motor and each reel can be driven by a 5-hp or a 1½-hp d-c reel motor. Amplidyne control of tension is provided.

In contrast to this small mill, another mill is being designed at the present time to roll 40-inch wide strip at 1500 fpm. This mill requires the use of a 2500-hp double-armature d-c motor for the main rolls and two 1000-hp d-c motors for each reel. Adjustable voltage control and amplidyne tension control are being used.

In order to analyze the problem, it will be convenient to take a concrete example by assuming some typical mill data and to discuss the selection and operation of the various electrical components as we go along.

Let us assume that we are asked to recommend elec-

Figure 1 — Control panel for Sendzimir cold strip mill.



Presented before AISE Annual Convention, Cleveland, Ohio, October 3, 1946

trical equipment for the following mill as shown in Figure 2.

Product:
- Stainless steel (all grades)
- Initial gage — 0.065 in. (entering)
- Minimum gage — 0.005 in. (finishing)
- Maximum width — 25 in.
- Minimum width — 15 in.

Mill:
- Strip speed — 250/500 fpm
- Driven roll diameter — 5.031 in. (max)
  — 4.528 in. (min)
- Work roll diameter — 1.578 in.
- Mill motor — 400 hp, 600/1200 rpm
- Gear ratio — 3.16/1
- Maximum reduction per pass — 50 per cent

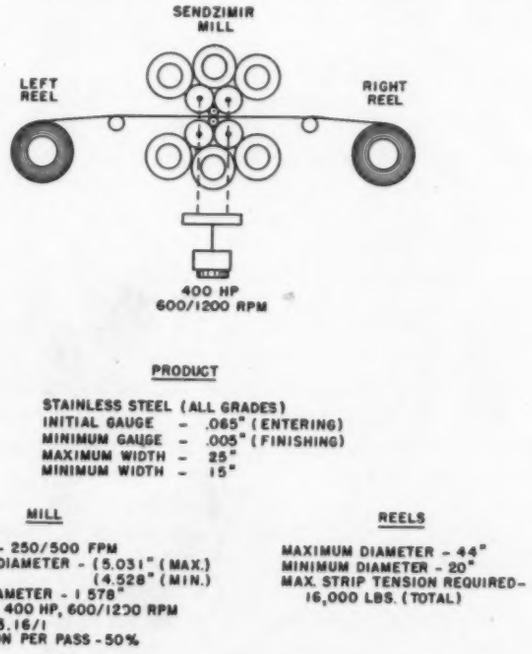
Reels:
- Maximum diameter — 44 in.
- Minimum diameter — 20 in.
- Maximum strip tension required — 16,000 lb (total)

SELECTION OF MILL MOTOR

Although the horsepower and speed range of the main drive motor are usually specified by the mill builder, there are other factors to be considered in arriving at the complete rating of this motor. It is necessary to consider such items as overload rating, voltage, single or multiple armature construction, and temperature rise. Obviously, there are other electrical and mechanical factors to be taken into account, but those mentioned are the ones which concern us today.

In general, the main drive motors for rolling mill service are rated either 40 C rise open, or 40 C rise forced ventilated. In either case, the machines are usually supplied with air under pressure from an external source in order to keep them clean and to allow

Figure 2 — The data given is for an assumed typical Sendzimir mill used in the sample computations.



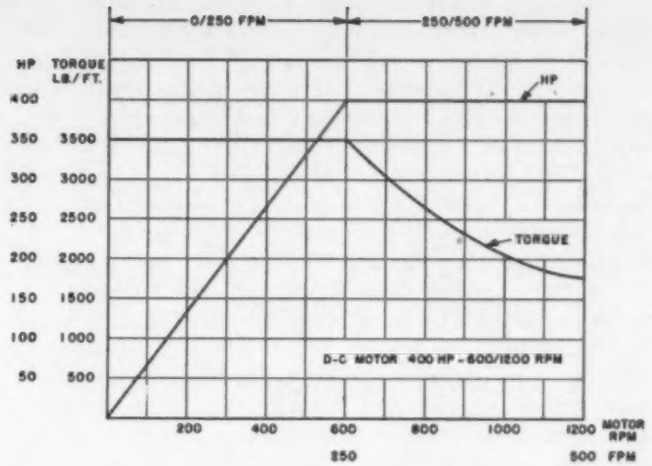
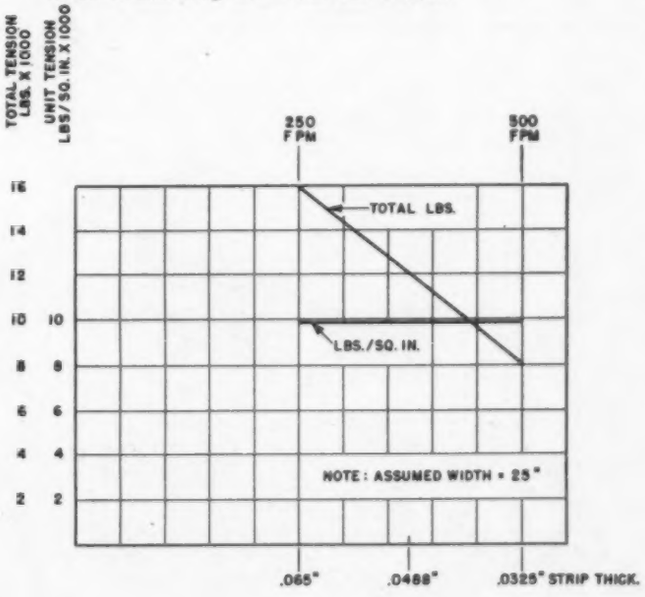


Figure 3 — Speed up to 250 fpm is controlled by adjusting the armature voltage. Above that speed, weakening the shunt field controls the strip speed.

for low speed operation. The difference is that the 40 C rise open machine will not exceed its temperature rating at 100 per cent rated load at any speed between basic and top speed even if the external ventilation and ventilating covers are removed; whereas, the other motor, which is usually smaller, normally requires the use of external ventilation in order to stay within its rated temperature rating under similar conditions of load and speed.

Experience in cold rolling has shown that even though the screw settings remain unchanged, the gage will tend to run heavier as the strip speed is lowered and lighter as the strip speed is raised. In order to minimize the amount of off gage material at each end of the coil, it is desirable to accelerate and decelerate the mill as rapidly as possible between passes. The total WK^2 to be accelerated and decelerated is, therefore, of great importance and it is usually desirable to select the smaller motor when an appreciable decrease in WK^2

Figure 4 — If strip tension stress is constant, the total tension will vary with the reduction.



is possible. It so happens that in the case of the 400-hp motor under consideration the difference in WK^2 between a 40 C open motor and a 40 C forced ventilated motor is relatively small; however, in the larger, low speed, machines this factor becomes extremely important and the 40 C rise forced ventilated motor with its lower WK^2 should always be given careful consideration.

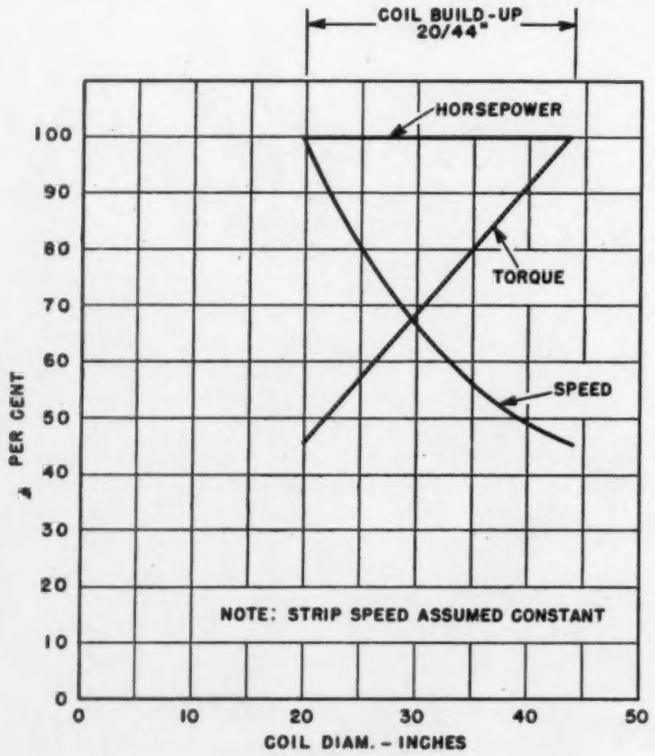
Another factor which affects the WK^2 is the use of single or multiple armature construction. Again, this is not so important in small machines, but it does have to be considered in such cases as the 40-inch wide Sendzimir mill now being designed which requires a 2500-hp driving motor. Of course, in the larger motors good design practice may dictate the use of multiple armature construction even without any consideration of the reduction of WK^2.

In so far as voltage is concerned, the smaller machines logically fall into the 250-volt class and the larger ones into the 600-volt or higher class. The voltage to be used is usually determined by the overall economics of the situation and fortunately this usually falls in step with good design practice. For our particular example, 250 volts would appear to be slightly more economical.

As a usual thing, all 40 C rise mill motors are suitable for 125 per cent load for two hours without exceeding a 55 degree rise, and are designed for infrequently repeated 200 per cent commutating peaks.

After considering all of the above factors, we might logically select a single armature, 400-hp, 40 C open continuous, 600/1200-rpm, 250-volt d-c motor with provision for forced ventilation.

Figure 5 — Required reel motor characteristics during coil build-up.



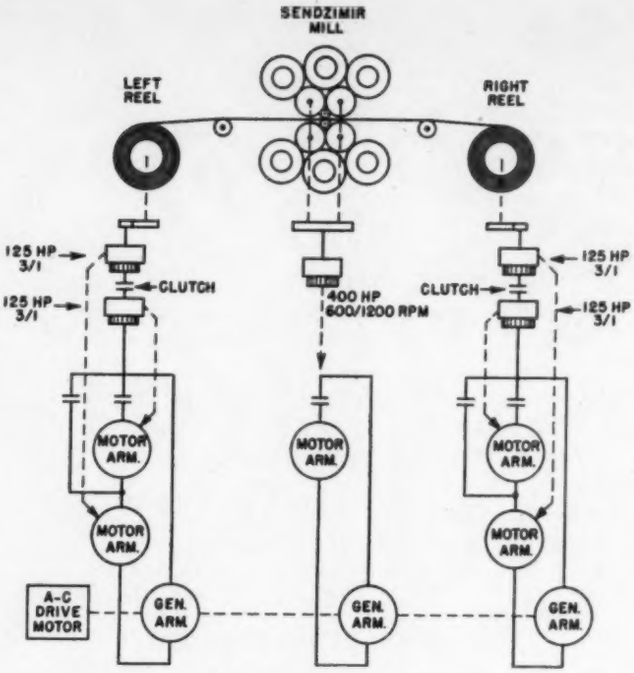


Figure 6 — Armature circuits when two reel motors are used on each reel.

SELECTION OF REEL MOTORS

Whereas, in the case of the main mill motor it is usually desirable to make it plenty large and sometimes to make it a little larger than seems necessary in order to be on the safe side, this is not the case in selecting the reel motor. In the first place, inertia assumes a role of even greater importance in the selection of the reel motor and, secondly, the range of tension over which the reel has to operate successfully requires careful consideration. Both of these factors necessitate the use of as little horsepower and as low WK^2 in our reel motor as is practical. In fact, it is quite often desirable to keep the reel motor small and to put up with more frequent maintenance work than to sacrifice the performance of the mill.

Quite often reel motors are rated on a 60 C rise forced ventilated basis with Class B insulation in order to keep the inertia to a minimum. Furthermore, the 125 per cent, two-hour load rating is often sacrificed although the 200 per cent peak commutating rating is retained. Obviously, good judgment is called for in reaching the best overall compromise.

In so far as voltage is concerned, the same comments apply to the selection of the reel motor as were previously given for the main mill motor.

The data given in Figure 2 indicates the following:

Strip speed — 250/500 fpm

Maximum reduction — 50 per cent per pass

Maximum tension — 16,000 lb (total)

Reel diameter — {44 in. maximum; 20 in. minimum}

Driven roll diameter — {5.031 in. (maximum); 4.528 in. (minimum)}

The strip speed will be changed from zero to 250 fpm by raising the armature voltage applied to the

main drive motor. From 250 fpm to 500 fpm, the mill motor armature voltage will remain constant and the strip speed will be changed by weakening the shunt field of the mill motor. This means, as illustrated in Figure 3, that twice the torque is available for rolling at 0/250 fpm as is available for rolling at 500 fpm. As a result, the earlier, heavier reductions will probably be taken at the lower speeds and the later, lighter passes taken at the higher speeds. This is important since it affects the selection of the reel motor.

Determination of reel motor horsepower — Substitution in the formula:

$$\text{REEL HP} = \frac{\text{TOTAL TENSION (lb) x FPM}}{33{,}000}$$

will give the required horsepower input to the strip at any given strip speed. If we assume that 16,000 lb tension is required at all speeds up to and including 500 fpm, we immediately arrive at values of 121 hp at 250 fpm, and 242 hp at 500 fpm. This is sometimes the case, but more often the strip is rolled at progressively higher speeds as the gage decreases and as a result, if we assume that the tension in psi remains practically constant at all speeds, the desired total tension decreases as the speed increases. This can be readily seen in Figure 4, where it has been assumed that the rolling speed increases from 250 fpm to 500 fpm as the strip gage decreases from 0.065 in. to 0.0325 in. with the tension in psi remaining constant and the total tension decreasing directly with the gage. Further reduction from 0.0325 in. to 0.005 in. could, of course, be taken at 500 fpm without exceeding the available tension.

In order to select a reel motor to fit such a curve exactly, we would require one which would develop 121 hp at all speeds between 250 and 500 fpm. Whether or not this is feasible will develop as we investigate the other factors such as reel motor speed range, etc.

Determination of reel motor speed range — As in the case of the main motor, the reel motor speed will be controlled by a combination of armature voltage and motor shunt field adjustment. The relative amounts of speed control of the reel motor which are obtained in these two ways are, however, extremely important in designing a good operating equipment.

To begin with, as shown in Figure 5, the reel motor speed must vary inversely with the coil diameter when the mill is delivering strip at a constant rate of speed. Furthermore, the horsepower output of the reel motor must also remain constant during this time, if we are to maintain constant pull or tension on the strip. The effect of friction in the reel is being neglected temporarily although its effect will be discussed later.

D-c motors are inherently able to deliver constant horsepower when the speed is changed by adjusting the shunt field excitation of the motor, since the available motor torque increases as the motor speed decreases. On the other hand, if the change in speed is accomplished by varying the armature voltage and at the same time keeping the shunt field excitation constant, the available motor torque remains constant and the available horsepower increases or decreases directly with the motor speed. It is thus evident that our reel motor should have enough speed range by shunt field

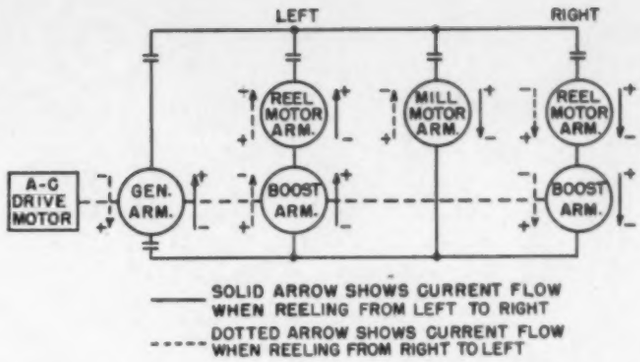


Figure 7 — Typical reel armature circuit with booster generators.

control to compensate for the reel build-up or build-down as the case may be.

In addition, it is desirable to provide sufficient speed range in the reel motor to allow for variations in strip speed due to wear or grinding down of the work rolls or driven rolls of the mill. Furthermore, some excess speed must be available so that the tension regulator can automatically adjust the shunt field of the reel motor over the required range for build-up or build-down and mill roll variation without running up against a limit at either end of its operating range. This excess speed required is usually about 20 per cent with 5 per cent being allowed at the high speed and 15 per cent being allowed at the low speed end.

In order to provide constant pull on the strip as the coil diameter changes and to allow for roll wear and regulator margin, our reel motor must then have a speed range of:

$$\frac{44 \text{ in.}}{20 \text{ in.}} \text{ (coil build-up)} \times 1.1 \text{ (roll wear)} \times 1.20 \text{ (regulator margin)} = 2.9/1 \text{ (approximately)}$$

Therefore, if 16,000 lb total tension is required at all operating speeds up to 500 fpm, we would select a standard rating of 250 hp, 3/1 speed range; but, if maximum tension is required only up to 250 fpm, we have an additional problem. As previously pointed out, we would then want 121 hp available anywhere between 250 and 500 fpm. A 125-hp reel motor having a speed range of 2.9/1 for build-up, etc., and an additional 2/1 speed range for strip speed, or a total of 2 × 2.9/1 or 5.8/1 would meet this requirement. However, such a 125-hp, 6/1 motor would be a very poor commutating machine and it would cost just as much as, or more than, a 250-hp, 3/1 motor.

A third and a better solution to the problem would be the use of two reel motors on each reel. Figure 6 shows the armature circuits for such a combination. In order to draw this diagram, it has been assumed that separate generators will be used for the two reels and the main motor, this particular point will be discussed later.

Here we have two 125-hp, 3/1 speed range motors mechanically coupled together through a clutch and operating with their armatures connected electrically in series for one condition of operation when the gage is heavy and the speeds are slow. This combination gives a total of 125 hp and 16,000 lb tension on each reel at a

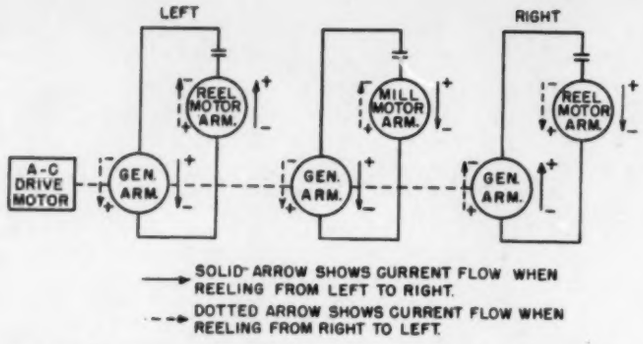


Figure 8 — Typical reel armature circuit with separate generators.

strip speed of 250 fpm. This same tension is available from zero to 250 fpm. When operation above 250 fpm up to 500 fpm is required for the lighter gage material, one reel motor on each reel is disconnected both electrically and mechanically, and 8000 lb tension is then available between 250 fpm and 500 fpm. The advantages of this scheme are reduced generator size since the generator needs only be large enough to handle a total 125 hp at any time, better operating motors since the speed range is only 3/1, lower inertias when lighter gages are being rolled, and possible wider ranges of tension control. More will be said about these latter two points later.

SELECTION OF GENERATORS

If we assume that we have selected two 125-hp, 3/1 speed range, 60 C forced ventilated motors for each reel, we can now determine how generator capacity is required to supply power to both the mill and reel motors.

Much has been said and written about the use of booster generators versus separate generators for the reels. Figure 7 shows a typical reversing cold mill armature circuit with boosters, and Figure 8 shows a similar armature circuit with separate reel generators instead of boosters. Years ago, it was common practice to use two boosters of different sizes and transfer the higher voltage booster to the unwinding reel motor after each pass. This scheme had the obvious disadvantage of losing stalled tension during the transfer and up-to-date practice, therefore, dictates the use of two full sized boosters or two separate reel generators.

The fact of the matter is that either two full size boosters or two separate reel generators can be made to give equally satisfactory results. Reference again to Figures 7 and 8 will illustrate that in neither case does the reel motor armature current reverse when the mill is stopped and reversed. In both cases all generator, booster and motor polarities reverse, but since the reels alternately change from motoring to generating action, and vice versa, the flow of current through each reel motor armature is undirectional. As a result, the reel motor current never completely collapses and tension is never completely lost.

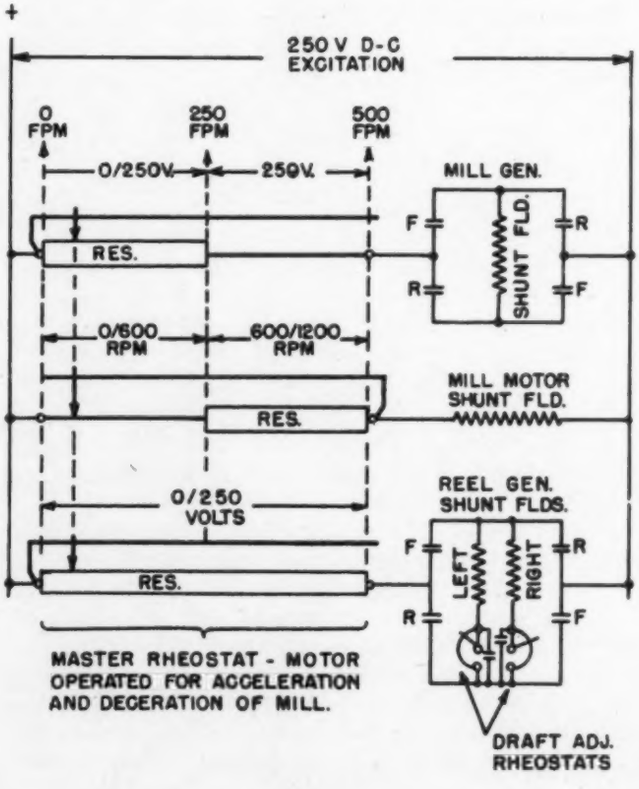
In view of the above, the choice between boosters and separate generators becomes one of economics only. Obviously, the unwinding motor must run slower than the winding motor, even with the same diameter of coil, since the strip is thicker on the unwinding side. The unwinding reel motor is operated at this slower speed by decreasing the voltage applied to its armature. In the case of the boosters, this means more voltage output from the unwinding reel booster, and the amount of this voltage is determined by the reduction or draft being taken on the strip and the shunt field setting of the motor driving the mill rolls. When separate reel generators are used, the voltage of the unwinding reel generator is lowered as the draft is increased.

When the maximum draft to be taken is 50 per cent, the maximum booster voltage available must then be on the order of 50 per cent of maximum bus voltage or more. If the field of the 600/1200 rpm main mill motor is adjusted for base speed operation, as much as 75 per cent of maximum bus voltage may be required from the booster in this particular case. Consequently, the booster size increases as the maximum draft and speed range of the mill motor increase, but the separate generator remains the same since its voltage can be reduced indefinitely.

Practice has shown that if it is necessary to have in the neighborhood of 50 per cent booster volts available or if there is a chance of increasing the maximum draft at a later date, it is desirable to start out with separate generators.

In some cases, one additional advantage of separate generators may accrue. Our motors are so small that both the reel and mill motors logically fall into the 250-volt class from the standpoint of design and price. However, the use of separate reel generators allows us to use 600 volts on the main roll motor and 250 volts

Figure 9 — Typical field excitation circuit for Sendzimir mill.



on the reel motors on those occasions where it may become desirable.

We will then require a 350-kw, 250-volt generator for the 400-hp main motor and two 125-kw, 250-volt generators for the reels.

METHOD OF CONTROL

The control circuits are, of course, "the brains" of a reversing cold strip mill just as they are "the brains" of numerous other processes in the steel mill, and it is extremely important that the control equipment be designed properly.

Field circuits — Figure 9 shows the typical field circuits for such a mill. One common motor-operated rheostat is used for accelerating and decelerating the entire mill. Full field is maintained on the mill motor while the mill generator voltage is increased from zero to 250 volts. From this point on the mill generator remains at 250 volts, and the mill motor shunt field is weakened. Simultaneously, the reel generator voltage is increased uniformly and reaches a maximum at the same time the mill motor reaches top speed.

Draft adjusting rheostats are used to adjust the voltage of the unwinding reel generator and these can be set for the approximate draft to be taken. As the mill is reversed, the draft adjusting rheostat is automatically switched into the field circuit of the correct generator.

Current regulators — Figure 10 shows a typical amplidyne current regulating circuit for holding tension in the winding reel. The unwinding reel circuit is similar except that the amplidyne field polarities are reversed. An amplifying exciter measures the voltage drop across a resistor in the reel motor armature circuit, and in turn excites the control field of the amplidyne buck-boost exciter. The amplidyne buck-boost exciter increases the excitation of the reel motor and slows it down as the coil diameter increases. The reference field excites the buck-boost exciter in a direction to weaken the reel motor field, and its action is similar to that of the spring on an ordinary regulator. The speed limit field opposes the action of the reference field and limits the maximum speed or threading speed of the reel motor as the case may be. The tension adjusting rheostat determines the reel motor armature current necessary to excite the amplifier sufficiently to cause the control field to properly oppose the effect of the reference field.

Obviously, the amplifier must change the control field excitation of the buck-boost exciter a sufficient amount to carry the reel motor from its maximum speed to approximately its basic speed during the course of the coil build-up. In order to do this, the current in the reel motor armature must increase a slight amount as the coil builds up, and this slight increase is a measure of the accuracy of the current regulator. Since this increase in reel motor current represents a constant increase in volts across the armature resistor, the per cent change in reel motor current will be greater for low currents and light tensions than it will be for high currents and high tensions. The inherent accuracy will thus be less for lighter tensions.

Practice has shown that a 10/1 range of tension control of current adjustment is a practical maximum when using only one reel motor, and in some instances this range may be as low as 7 or 8 to 1. On the other hand,

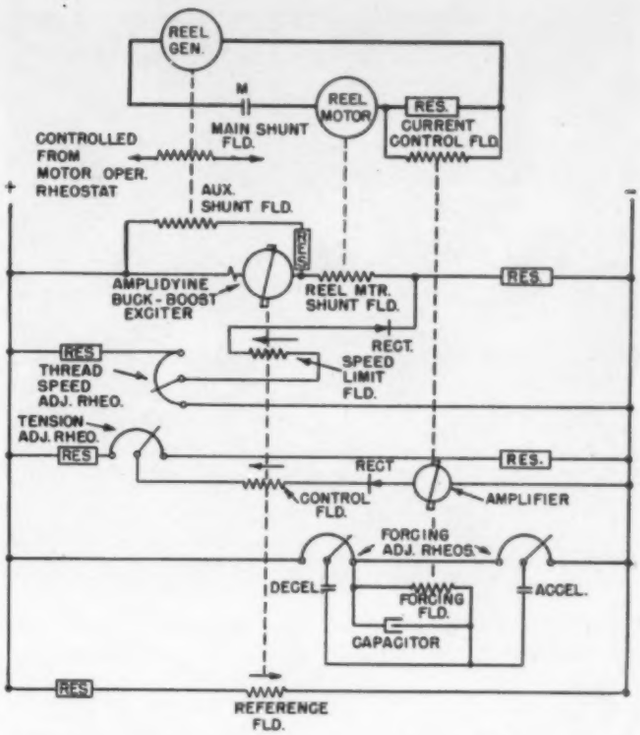


Figure 10 — An amplidyne current regulating circuit is used for holding tension in the winding reel.

if two reel motors are used in the manner previously discussed, the practical range can be made about 20/1.

In discussing the possible range of tension adjustment, however, the effect of mechanical losses must not be overlooked. It is a well known fact that the mechanical losses of the reel decrease as the speed decreases and holding constant reel motor current does not insure that the tension is constant. This factor is especially important on reels with high gear ratios or where very light tensions are being held. As means of compensating for the effect of mechanical losses in the winding reel, an auxiliary field of the generator or reel booster can be connected across the buck-boost exciter as shown in Figure 10. As the reel slows down and the losses decrease, this auxiliary field on the reel generator decreases the reel generator voltage slightly, and reduces the total kw input to the reel, thereby, maintaining a more uniform tension. At the same time, this same corrective means also tends to compensate for the slight increase in reel motor current during the build-up of the coil. In the case of the unwinding reel it is desirable to minimize this change in reel generator voltage to the point where it only compensates for the change in IR drop of the circuit, since the mechanical losses and the resultant strip tension tend to increase as the coil diameter decreases.

One other important item in connection with current regulators is the matter of "forcing." A current regulator tries to maintain a definite, predetermined armature current for steady state running conditions. During acceleration we must hold more than normal current in the winding reel motor and less than normal current in the unwinding reel motor in order to compensate for the inertias of the reels. During deceleration, the opposite is required. It is thus necessary to "fool" the regulator into holding more or less current as the case

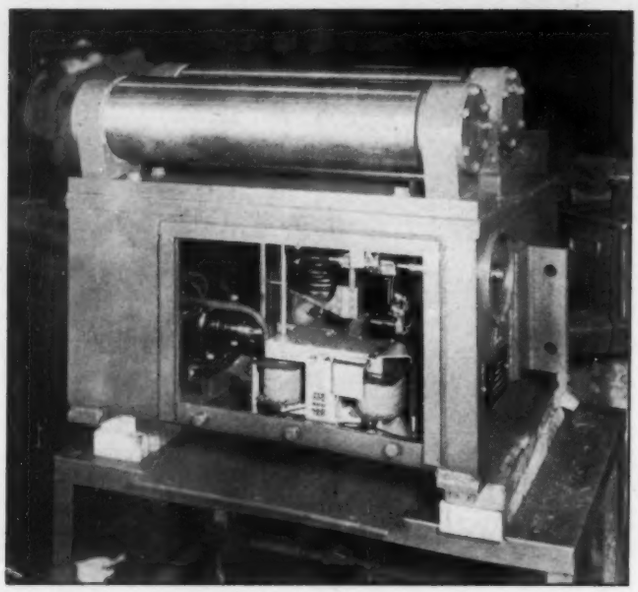


Figure 11 — Three-roll type regulating tensiometer for controlling reel.

may be. This may be done in numerous ways with transformers, capacitors, or modified block forcing as shown in Figure 10. Here the normal excitation of the amplifier is automatically opposed during acceleration and aided during deceleration. The relative amounts are independently adjustable since friction tends to increase the necessary accelerating current and decrease the necessary decelerating current.

Previous mention has been made of the desirability of keeping the reel motor inertia to a minimum. Under some conditions, the reel motor may have to carry normal armature current for maintaining the necessary tension, and at the same time carry enough additional armature current to accelerate the heavy mass of the reel and coil, as well as its own inertia. Where gears of any sizeable ratio are used between the reel and reel motor, the reel motor armature stored energy is quite apt to be the predominating feature. Furthermore, since the torque available for accelerating the WK^2 of the mill is usually greater than the torque available for accelerating the WK^2 of the reel, the reel motor is quite often at a disadvantage in trying to keep up with the accelerating rate of the mill.

Regulating tensiometers — Where wider ranges of tension control are necessary than can conveniently be obtained by the use of current regulators, regulating tensiometers are sometimes used. Figure 11 shows such a tensiometer which is now in use on a cold strip mill reel. This particular tensiometer is of the three-roll type with the outer rolls acting to maintain the pass line of the strip accurately at all times. Single roll regulating tensiometers have been built, and in these cases it is necessary to have external supporting rolls which serve the function of maintaining a uniform pass line.

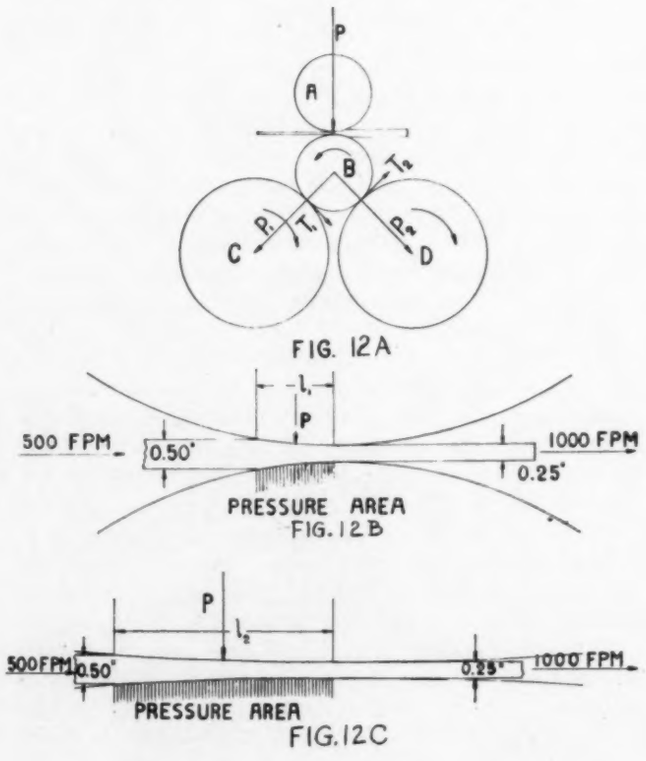
The actual strip tension and resultant vertical pressure on the middle roll is converted into an electrical signal by means of an air-gap transformer. The resultant electrical signal is used to indicate the actual strip tension on an indicating instrument as well as to control the excitation of the reel motor. The overall regulating circuit for the reel becomes similar to that shown in Figure 10 for the current regulator if we excite the control field of the amplifier from the tensiometer rather than from the drop across a resistor.

The regulating tensiometer inherently provides for the necessary "forcing" during acceleration and deceleration, but since the actual rate at which the reel can change speed is limited by commutating capacity of the motor, the tensiometer is at the same disadvantage as the current regulator if the inertia of the reel is too high.

In dealing with tensiometers, however, it should be remembered that they are mechanical devices and as such have mechanical inertia and friction just the same as any mechanical regulator. A well designed tensiometer has the practical minimum of inertia and friction and is designed to move through a very small distance of approximately 0.1 inches maximum, but at the same time it must be strong enough to withstand the maximum pressure to which it will be subjected by the strip.

Current regulator or tensiometers — The question now arises as to whether we should apply a current regulator or a tensiometer to the mill under consideration. If we assume that it will be necessary to hold the same unit tension in psi for 0.005 in. × 15 in. strip as for 0.065 in. × 25 in. strip, the total range tension required is approximately 21.5/1. If we were planning to use one full sized reel motor on each reel, such a wide range of tension adjustment would be impractical with current control. On the other hand, the use of two reel motors on each reel increases our practical range of tension adjustment by current control to about 20/1, and it, therefore, appears that the current regulator would barely get by. However, we are dealing with a border-

Figure 12 — Forces acting on rolls in Sendzimir mill.



line case, and since the increased cost of regulating tensiometers would be a very small part of the cost of the entire mill, it would seem desirable in this particular instance to utilize both the tensiometer and the current regulator for tension control, or at least to make provision for adding the tensiometers at a later date if found necessary.

The current regulator can be used during the early passes when the strip is thick, the tension is heavy, and the mechanical losses of the reels have relatively little effect. The tensiometer can then be used during the finishing passes when the strip is thin and the tension is light. This combination allows the use of a regulating tensiometer of lighter weight and less inertia than would otherwise be possible and lets each type of tension regulator perform in the region in which it is most effective.

CONCLUSION

There are, of course, numerous other factors which must be considered from time to time in selecting electrical equipment for a reversing cold strip mill, but it has been our intent to cover briefly the most important ones. It should also be added that since the Sendzimir cold strip mill is usually designed to roll down to very thin gages, these factors are quite apt to assume greater significance in the selection of electrical equipment for a Sendzimir cold strip mill than in the selection of electrical equipment for a conventional 4-high reversing mill.

♦♦

DISCUSSION

PRESENTED BY

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A. F. Kenyon: The author has given a very complete and comprehensive review of the many factors involved in the selection of the electrical drive equipment, not only for the specialized Sendzimir type mill, but for any single stand reversing cold strip mill. The arrangement of the rolls in the Sendzimir type mill is unique, however, the requirements of the electrical equipment are very much the same as for a conventional four-high mill.

One factor which may dictate some difference in the drive equipment is the matter of possible reduction that can be made in a single pass through the mill. On conventional mills, rolling softer grades of strip, reductions may be of the order of 35 to 45 and seldom exceed 50 per cent. The Sendzimir mill, with its rigid construction and small diameter working rolls, is capable of making drafts as large as 75 per cent, even 80 per cent has been observed. Of course, on hard materials like stainless steel, the drafts may be quite moderate, say of the order of 15 to 25 per cent. This means then that the speed of the strip entering the mill may range from 15-20 to 75-85 per cent of the speed of the strip leaving the mill, and the unwinding reel must be controlled in a manner to afford accurate tension regulation over this large range of draft.

On a conventional four-high reversing mill, where the drafts are moderate and do not vary over a wide range, a speed pilot reference from the mill drive or a circuit in the main speed adjusting rheostat indicative of mill speed, may be utilized to control the voltages applied to the winding and unwinding reel motors. Such an arrangement was illustrated in the diagram shown by the author. However, as also shown in the diagram, such an arrangement requires a "draft" rheostat, to be set for the approximate draft being taken, to vary the unwinding reel voltage in proportion to (1 — draft), as well as in proportion to the mill speed. Most mill operators object to having to use a draft rheostat as it imposes an additional burden on the operator, and the reel tension regulator may run out of range if the rheostat is not properly set.

This difficulty may be overcome by driving speed pilot reference machines from the deflector rolls, thus obtaining direct measures of both the strip delivery speed and the strip entry speed which may be utilized to control the winding reel voltage and unwinding reel voltage, respectively. Some such drives have been built, although caution is necessary to assure that even at the lightest tensions the deflector rolls will be driven without slippage. This method of reel control makes unnecessary any draft rheostat as the unwinding reel is made responsive to strip entry speed, also it may be advantageous on the winding reel as the strip delivery speed reference eliminates variations due to changes in mill roll diameter, slippage between driven and working rolls, extrusion of strip, etc.

Another method of reel control utilizes a measure of coil diameter to control the reel motor excitation, with the usual constant current regulator controlling the reel supply generator. This arrangement also eliminates the draft rheostat, makes unnecessary any separate IR drop compensation, and performs with the same accuracy at slow speed or stalled tension as at normal rolling speeds.

The use of regulating tensiometer control for the winding and unwinding reels has been mentioned. Several small Sendzimir mills have been built with regulating tensiometer control, and there is under construction a 37 in. wide mill, with 400 hp mill motor and two 300 hp reel motors, to roll stainless steel strip at speeds up to 400 fpm, where regulating tensiometers will be used to control tensions up to 40,000 pounds maximum.

The effects of friction in the bearings and gearing of a reel drive, which are corrected by the use of regulating tensiometers, are illustrated by data obtained from the trial operation of a small Sendzimir mill set up in the

mill builder's shop. This particular mill was driven by a 15 hp mill motor and two 5 hp reel motors. It was reported that the tension during the early passes approached 1000 pounds, requiring some 150 to 175 per cent output from the 5 hp reel motors. Then as the strip was reduced to a final gage of 0.0006 in., the required tensions were reduced to about 50 pounds. Under stalled condition these tensions required about 2 amperes through the armature of each reel motor. Then as the mill was started, the reel frictions were such that at 50 fpm the winding reel motor current increased to about 3 amperes while the unwinding current dropped to zero; and as the speed was further increased to 200 fpm (the maximum for this small laboratory mill), the winding reel current further increased to 4 amperes and the unwinding reel current reversed to 1 ampere negative. Thus the currents required to develop torques to overcome frictions were just about the same as to exert the desired tensions in the strip. The tensiometers, responsive directly to strip tension, automatically compensate for these variations in friction, as well as for inertia, IR drop, etc., whereas constant current regulators would have to have separate compensations for these variables.

T. B. Montgomery: I would just like to ask the question as to what total reduction from entry to finish has been found practical on the mill?

There are just a few points I might give you. A mill that has not yet gone into operation is one for which our company is furnishing equipment. It is a 1000 fpm mill, and it has three reel motor tension combinations, using fifteen horsepower motor entry and delivery and two seventy-five hp which we can use either singly or together in tandem. The motors can be clutched in and out for three combinations of tension settings with the normal four-to-one variation of each one of the combinations. The main motor is 750 horsepower.

The circuits are arranged for separate generators for the reels and main motor. The mill does not use the mechanical tensiometer, that is, the regulating tensiometer. We use current regulators.

Tension control is by measure of the reel diameter and by constant current from control of the generator voltage through a separate regulator, as Mr. Kenyon mentioned.

T. Sendzimir: I want to say a few words about two things that Mr. Kenyon just mentioned, first is the friction drive on the rolls, in which we have made extensive tests. There is absolutely no slippage between the rolls and the driving rolls.

Figure 12 illustrates the situation. If we apply the torque to the two driven rolls C and D in order to drive lower work roll B, then we have the resultant pressure on the roll P, which is called the "roll separating force," being taken up by the driven rolls.

These components P^1 and P^2 are roughly seventy per cent of the main force; that is, for every 100 tons of roll separating force, we have about 70 tons taken up by each one of the two rolls, or a sum of 140 tons. The torque on work roll B is actually produced by the tangent forces T^1 and T^2 which are 70 tons for each roll multiplied by the co-efficient of friction, so that there is quite a margin of safety.

With the high pressure between the rolls, the one being the driving, the other the driven roll, we have a small area of contact. It is so small, that lubricant is pressed out. We do not have any oil film there. We have a semi-fluid friction between the two, and had there been the slightest slippage between these rolls, heavy wear on both the driving and the driven rolls would occur. We have had experience with these for some years, and there has not been the slightest marks of any wear. Very careful checks on the speeds of the rolls were made, which showed that there is no danger of any slippage at all at the point of torque transmission.

Moreover, that torque is transmitted over the whole length of the work roll.

These mills range from the smallest, where the diameter is only 7/16 inch and the length 10½ in., up to the larger rolls, as we build them now, with a diameter of about 2 5/16 in., with a total length of 54 in. in one mill and longer in some other mills.

The roll itself is subject to no torsional stresses whatsoever, which is an advantage because of the fact that certain analyses of steel can be used for the work rolls that would otherwise be too brittle, if they had to stand the torque. We have certain grades of steel that are very hard and have a very high resistance to abrasion but are rather poor in transmitting torque. In this case, these kinds of alloy steels can be used and give very long wear on certain metal strips that have an abrasive surface.

This brings us to the second matter discussed by Mr. Poole and Mr. Kenyon. The entering speed of the strip is slower than the leaving. If a very heavy pass is taken, the difference is quite pronounced. Let us assume that we are speaking of a fifty per cent reduction, entering at 0.050 in. and leaving at 0.025 in. strip thickness and let the exit speed be, say, 1000 feet per minute. Then the entry speed is 500 feet per minute, which means that in the bite of the roll there will be slippage of 500 feet per minute.

It can be clearly seen from the sketches of Figure 12 that this slippage, in case of large rolls, will take place over a wide area in that long roll bite, and on small rolls over a smaller, narrower area in a more open roll bite, which means much less wear on the rolls. There are some alloy steels that cannot be properly pickled and are always abrasive to a certain extent. In the case of small work rolls, besides being able to use certain alloy steels that are better for such purposes, we also have the inherent advantage of considerably reducing that travel under conditions of slippage with the enormous pressure in the area of the roll bite.

It is a known fact that back tension applied to the strip materially reduces the roll separating force P. A large part of this relief is lost in case of large work rolls, due to the high friction prevailing between the strip and the roll surface, within the roll bite. This loss is progressive as the strip travels through the roll bite towards the point of exit, because the effect of friction is cumulative. A comparison between Figure 12C showing large rolls and Figure 12B showing small rolls clearly demonstrates that the small rolls will permit a fuller realization of the back tension for relief of the roll separating force — and such reduced roll pressure tends to reduce friction still further.

It is possible to take an annealed stock of a heavy gage steel and reduce it in one single pass to a relatively

light gate and get good surface, good flatness, and gage accuracy, but I would not recommend that be done in each and every case. There are some metals which by their very nature will not stand very large single pass cold reductions for quite different reasons.

What I want to say is that in this case with rather heavy pass, we do not get practically any extrusion. The extrusion which we do get is rather heavier on lighter passes. The extrusion is governed, as far as I have been able to ascertain, more by the total bite angle than by the friction conditions in the roll.

I have often found much more extrusion on heavy rolls notably on hot rolling, for instance, sheets.

We know that with small rolls, the non-slip point is not so fixed as it is with large rolls. A slight increase in back tension will push it back. Slight increase in front tension will push it forward. It is more mobile, and yet we have never been able to find any considerable amount of extrusion, not more than maybe 1 to 1½ per cent.

L. M. McCaffrey: Mr. Kenyon and Mr. Sendzimir both talked about making reductions, heavy reductions, reductions over fifty per cent, and up to seventy-five per cent. What I want to know is, can you make that reduction with a starting band, a quarter of an inch thick?

T. Sendzimir: We ought to use quite different mill proportions. It is possible, but not in the mills that we actually have in operation. It could be done, but it would mean much larger mill proportions and therefore, an expensive installation. What I have given is a very typical example, from 0.020 to 0.003 in.

L. M. McCaffrey: In other words, the practical use of the mill is from light gages to still lighter gages. and not from a heavy band, making large reductions from the first pass on.

T. Sendzimir: Reductions should not be more than a certain percentage of roll diameter. We take 2 per cent as a practical limit. Using 1 in. diameter work rolls, we can reduce a 0.080 in. thick strip by as much as 0.020 to 0.060 in. which is 25 per cent, but we can also reduce a 0.030 in. strip by 0.020 to 0.010 in. in one pass which is 66 per cent.

L. M. McCaffrey: What I wanted to bring out was the difference between the standard cold reduction mill and the Sendzimir mill, and in my mind it is this, that on the standard cold reduction mills with the larger diameter rolls you can make your heavier reductions first, and then you taper off. On the Sendzimir mill you make your lighter reductions first and then increase for your heavier reductions.

T. Sendzimir: Right.

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Continuous Versus Batch Annealing

OF SHEET AND STRIP

. . . . even with the most modern equipment now in use, fuel and labor costs for normalizing appreciably exceed those of box annealing . . . . in addition, normalized sheets can approach the drawability of cold-reduced box-annealed sheets only when box annealed after normalizing . . . .

By T. F. OLT
Assistant Director
Research Laboratories
American Rolling Mill Company
Middletown, Ohio

▲ BOTH continuous and batch annealing processes have been utilized for many years in the processing of sheet and strip. In any further discussion on this subject, one must of necessity consider the many papers and discussions presented in the past. A survey of those presentations appearing in the Proceedings of the Association of Iron and Steel Engineers for the past twenty years, dealing with the annealing of sheets and strip, indicates that this subject has not been covered as fully as processing facilities that incorporate mechanical and electrical equipment to a greater degree.

Previous papers have presented new thoughts and equipment in both fields of annealing being considered, i.e., continuous annealing or "normalizing," and "batch" or box annealing. There has been some effort on the part of equipment manufacturers to popularize continuous methods of annealing as a means of shortening the time required for the processing of sheets, without too much consideration being given to either the quality of the sheets or the cost of the annealing. In this paper it is proposed to review the metallurgical characteristics obtained from both methods of annealing, the comparative mechanical properties of the products produced by variations in practice within the economic limits of each method, also statistics covering heat requirements for the different methods, and investment cost of the equipment. This discussion is intended to show that both continuous and batch annealing processes have a definite place in the processing of sheet and strip steel, that they are mutually supplementary, and that there is little possibility that one will completely displace the other in the near future.

One might ask the question, "Why anneal sheet or strip?" The answer is quite simple. It is done primarily to improve the workability of the sheet or strip; so as to make it more suitable for the many and varied applications in which it is used. To describe in detail what is necessary to improve workability necessitates first putting the problem in terms of a specific application. A large proportion of the tonnage sold in the form of hot rolled and hot rolled pickled sheets or strip of commercial quality is shipped without annealing, except that received in hot piling or coiling. However, as the thickness of the sheet rolled approaches the low limit at which a particular hot strip mill can be made to function successfully, the finishing temperature gradually decreases due to increasing radiation losses. Eventually a point is reached where the material is progressively hardened by mechanical work below a temperature at which rolling strains are relieved. Such material is more limited in its applicability to various types of fabrication than thicker material finished at a higher temperature. Therefore, some type of annealing is necessary.

When sheets and strip are specified in a thickness less than that rollable on a hot strip mill, or when surface requirements are such that the degree of surface perfection attainable on the hot strip mill is unsuitable, the common method of producing the sheet is by cold reducing the hot rolled sheet or strip, after pickling, to the desired thickness. Most cold reduction mills effect a reduction in thickness of at least 30 per cent or more, which yields a product relatively unsuited to any but the most simple of fabricating operations — such as blanking, curving to very liberal radii, etc. Consequently, in order to improve workability of cold reduced sheets, annealing is again employed. The type of annealing employed to improve workability on hot and cold rolled sheets or strip will depend on many factors, among which are:

1. The requirements of fabrication.

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2. The steel composition specified.
3. The previous processing before annealing.
4. Comparative cost.
5. Time allowed for processing to meet delivery promise.

Some of these factors are conflicting; so that there are occasions when a more expensive anneal, or one yielding less desirable mechanical properties or workability, is selected in order to speed delivery.

METALLURGICAL CHARACTERISTICS OF CONTINUOUS ANNEALING

Stated simply, the metallurgical requirements of annealing are to assure adequate workability and suitable grain size to fabricate an identified part without coarsening or other objectionable surface disturbances so that the fabricated part can be finished without extra cost to the fabricator. While this sounds simple, in practice it may turn out to be rather complex, particularly so when sheet and strip are subjected to increasingly severe fabrication. The problems involved in processing sheets for a most difficult drawing operation such as a Buick front fender, are different than those for a shell or head for a steel drum. To produce sheets and strip suitable for a wide variety of severe fabricating operations, the metallurgist employs a variety of combinations of hot reduction, cold reduction, batch annealing, and normalizing, with other finishing operations.

In general, hot rolled and hot rolled pickled sheets and strip that are to be subjected to more severe fabrication than can be accomplished consistently with the direct strip mill product are normalized to refine the grain structure, obtain more uniform hardness through the removal of variable residual hot rolling strains, and to improve the ductility. Normalizing can be carried out either in strip or in sheet furnaces by heating the sheet to 1750-1800 F, and cooling to room temperature. The normalizing operation affords an opportunity to vary the grain size and mechanical properties within limits to the fabricating requirements of the part for which the sheet is intended. The effect of variation of the rate of cooling from normalizing temperature on the grain size of the product has been shown before[1]* and is reproduced in Figure 1.

It can be noted by inspection that, in general, the slower the material is cooled from the normalizing temperature, the larger the average grain size will be. Grain size in turn also has an effect on the hardness of the material. Figure 2 shows the effect of the rate of cooling on the Rockwell hardness of mild steel sheets.

Because of the wide spread in values encountered in testing at this point in processing, the data have been plotted in the form of cumulative frequency distribution curves. A large part of this variation is due to segregation taking place during the period of the solidification of the ingot, but there is also some due to variations in the heating and rolling operations prior to normalizing.

Figure 3 shows the effect of the method of rolling on the Rockwell hardness after normalizing. It can be seen that cold-reduced material will be somewhat harder after normalizing than hot-reduced material. So far

*Numbers refer to the bibliography at the end of the paper.

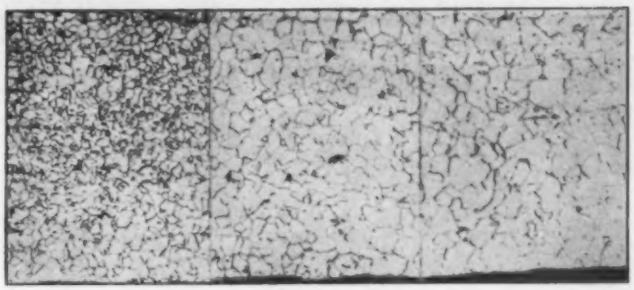


Figure 1 — Typical grain structure of normalized mild steel sheets cooled from normalizing temperature. Cooling rate at left was 185 F per minute, center rate was 44.5 F per minute, and rate on right was 30 F per minute.

these data all refer to normalizing performed on a chain type continuous normalizer using rider sheets. With this type of furnace it is possible to vary the cooling rate from normalizing temperature over a wide range simply by reducing the speed of the conveyor and increasing the number of sheets in a pack, thus maintaining approximately the same tonnage output per unit of time.

Inasmuch as a continuous strip furnace is generally limited to a single thickness the problem is different. In this case, the furnace must be designed for a given cooling rate at a definite tonnage output. It follows then that any increase taken in the cooling time can be offset only by a sacrifice in tons produced. Figure 4 shows the Rockwell distribution of the product from such a unit designed to normalize at 1750 F with a cooling rate of approximately 150 F per minute from 1750 to 1250 F for 0.035 in. thick strip.

Considerable laboratory investigational work has been conducted to determine the optimum cooling rates that can be employed in strip normalizing. The problem has been largely one of attempting to evaluate the benefits from making a softer sheet that would be more workable in a wider field of product application, as compared to the greater investment cost and increased operating problems encountered when the cooling zone is progressively lengthened to decrease the rate of transformation. In one such study we used material

Figure 2 — Effect of rate of cooling from normalizing temperature on the Rockwell hardness of mild steel sheets.

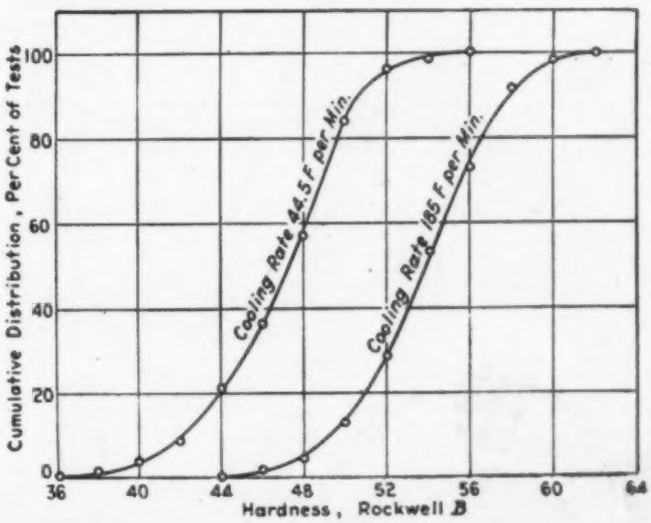


TABLE I

Effect of Cooling Rate Between 1800 and 1250 F on Rockwell Hardness and Tensile Properties

	Air cool	Rockwell "B"			
		960 F/min.	480 F/min.	240 F/min.	120 F/min.
Average	60	59.6	58.5	59.5	57.6
Maximum	68	67.5	67.5	67.5	67.0
Minimum	56	54.5	53.5	53.5	52.0
Spread	12	13	14	14	15
		Yield point			
Average	40,500 psi	.....	.....	.....	37,900 psi
Maximum	42,800	.....	.....	.....	42,200
Minimum	38,500	.....	.....	.....	35,400
		Tensile strength			
Average	52,300 psi	.....	.....	.....	52,500 psi
Maximum	58,200	.....	.....	.....	58,600
Minimum	50,000	.....	.....	.....	48,500

from sixteen different ingots, representing heats of the same grade of steel, and selecting material for testing from the top and bottom of the ingots. This was done to attain the extremes in segregation that might be expected. The composition was that of steel ordinarily used in sheet manufacture, made to a ladle analysis of 0.06 to 0.09 per cent carbon, 0.25 to 0.40 per cent manganese, 0.04 per cent maximum sulphur, balance residual.

Samples of each of the thirty-two locations from sixteen ingots were normalized in a laboratory furnace by heating to 1750-1800 F, soaking 2½ minutes, then cooling to room temperature using various rates between 1800 and 1250 F in addition to air cooling. The results of this particular test are given in Table I.

These figures indicate that the decrease in hardness possible by controlling the transformation rate is slightly more in the material initially softer than it is in the material initially harder. Further, it is demonstrated that the decrease in hardness from even these large variations in cooling rate is relatively small. To attain further reductions it is necessary to further reduce the cooling rate, and this in the case of strip normalizing means exceedingly long furnaces to provide the necessary cooling zone, or else the type of furnace described by Seabold.[2] This unit consists of a series of vertical loops with heat exchange and could probably be modified to produce a wide variation in cooling rate without a great increase in floor space as is required with a horizontal pass furnace. We do not have a furnace of this type in operation and are completely unfamiliar with its characteristics. However, we have had experience in horizontal pass furnaces and know that breaking of the strip is one of the chief problems responsible for delays in operation. The problem of threading a furnace after the strip is broken increases greatly as the length of the furnace is increased.

When cold-reduced material is being processed, recrystallization can be effected at temperatures considerably below those required for full normalizing. The general trend of such a practice is to progressively increase the average Rockwell hardness as the tempera-

Figure 3 — Effect of method of rolling on Rockwell hardness after normalizing.

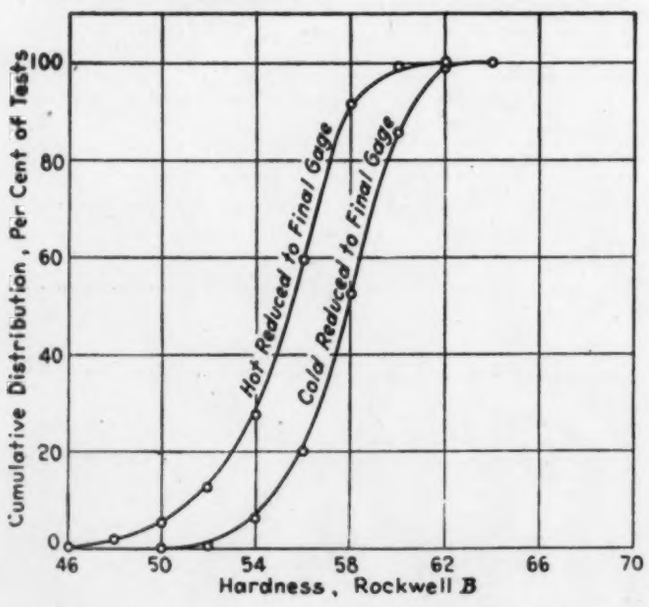
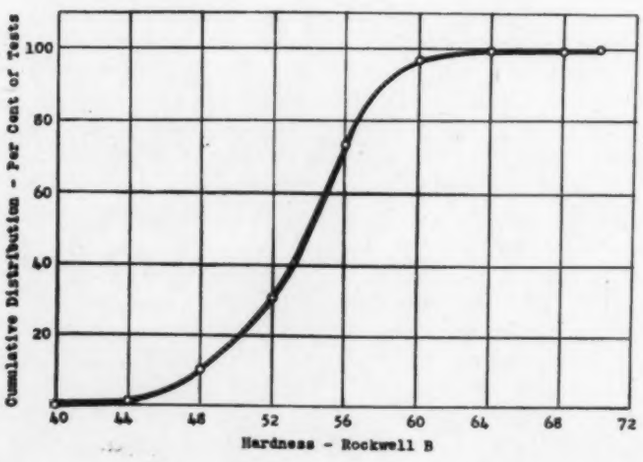


Figure 4 — Distribution of hardness values, strip normalized sheets.



ture is decreased below that at which full normalizing takes place. This has been shown by Seabold.[2] His values are somewhat below those shown in Table I because his are based on aluminum-killed steel, while those in Table I are on rimming steel.

METALLURGICAL CHARACTERISTICS OF BATCH ANNEALING

Control of grain size and hardness in batch annealing methods is effected by regulating the amount of cold reduction before annealing, together with the annealing temperature and time. As compared with normalizing, any batch annealing operation will require a greatly extended period of time for completion. As the name implies, "batch" annealing is performed on large groups of sheets or coils, which may vary up to as much as 100 tons in one charge, depending on the type of equipment used to perform the annealing operation. With such large masses of metal to be annealed, the heating rates and cooling rates must of necessity be slow. The total time required to perform the anneal is dependent largely on the mass to be annealed and may extend to as long as 80 hours for a 100-ton charge. Even with as small a charge as 20 tons, the annealing time is of the order of 60 hours, not considering the cooling period. The cooling period will vary from 100 to 140 hours depending on the size of charge.

Hayes and Burns[3] have shown the relationship existing between cold reduction, annealing temperature, grain size and mechanical properties in comprehensive detail and Figures 5, 6, and 7 are reproduced.

Figure 5 shows the relationship between the Rockwell B hardness of mild steel sheets and strip and the degree of cold reduction they have received.

In Figure 6a is shown the various degrees of distortion of the microstructure accompanying cold reductions from 0-60 per cent.

In Figure 6b are shown the various grain structures obtained after box annealing these same cold-rolled materials at 1100 F.

In Figure 6c are shown the microstructures of these materials cold reduced varying amounts and box annealed at 1350 F.

Figure 7 shows the effects of box annealing on Rockwell hardness, yield point, tensile strength, elongation in 2 in., and yield point elongation after annealing.

Some of the more important effects of various percentages of cold rolling and of box annealing temperatures on the material after box annealing are:

1. Material cold reduced below the critical degree of strain for a given annealing temperature does not recrystallize.
2. Cold reductions in the critical degree of strain for a given annealing temperature may recrystallize with a very coarse grain structure.
3. Material cold reduced in excess of the critical degree of strain recrystallizes with progressively smaller grain size as the per cent cold reduction is increased. This decrease in grain size is accompanied by increase in yield point and tensile strength and also in hardness.

It may be noted, however, that the hardness values (as measured on the Rockwell "B" scale) of all materials cold reduced to a degree where recrystallization takes place are considerably lower than the average obtained from a normalizing operation.

Figure 8 shows the distribution of Rockwell values of cold-reduced box-annealed mild steel as produced commercially. Box-annealed material has a spread of Rockwell values in the same pattern previously shown for normalized material. However, the distribution of values, while of the same total spread as normalized material, is more closely compacted around the mean value. This can be seen by comparing Figures 4 and 8.

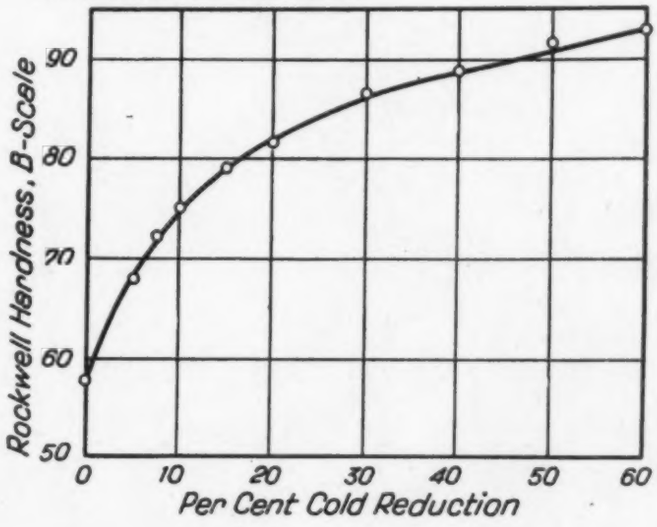
The hardness of normalized material can be made to approach that of cold-reduced and box-annealed material either by using extremely slow cooling from normalizing temperature or by box annealing the normalized material at a temperature high enough to relieve the cooling strains from normalizing. This practice is frequently used in the processing of hot-reduced material when the requirements of fabrication are such that a sheet normalized only is too stiff to perform satisfactorily. Such a practice is generally more expensive than one involving only cold reduction and box annealing and is not used except in such cases where it is impossible to use the cold reduction-box annealing practice.

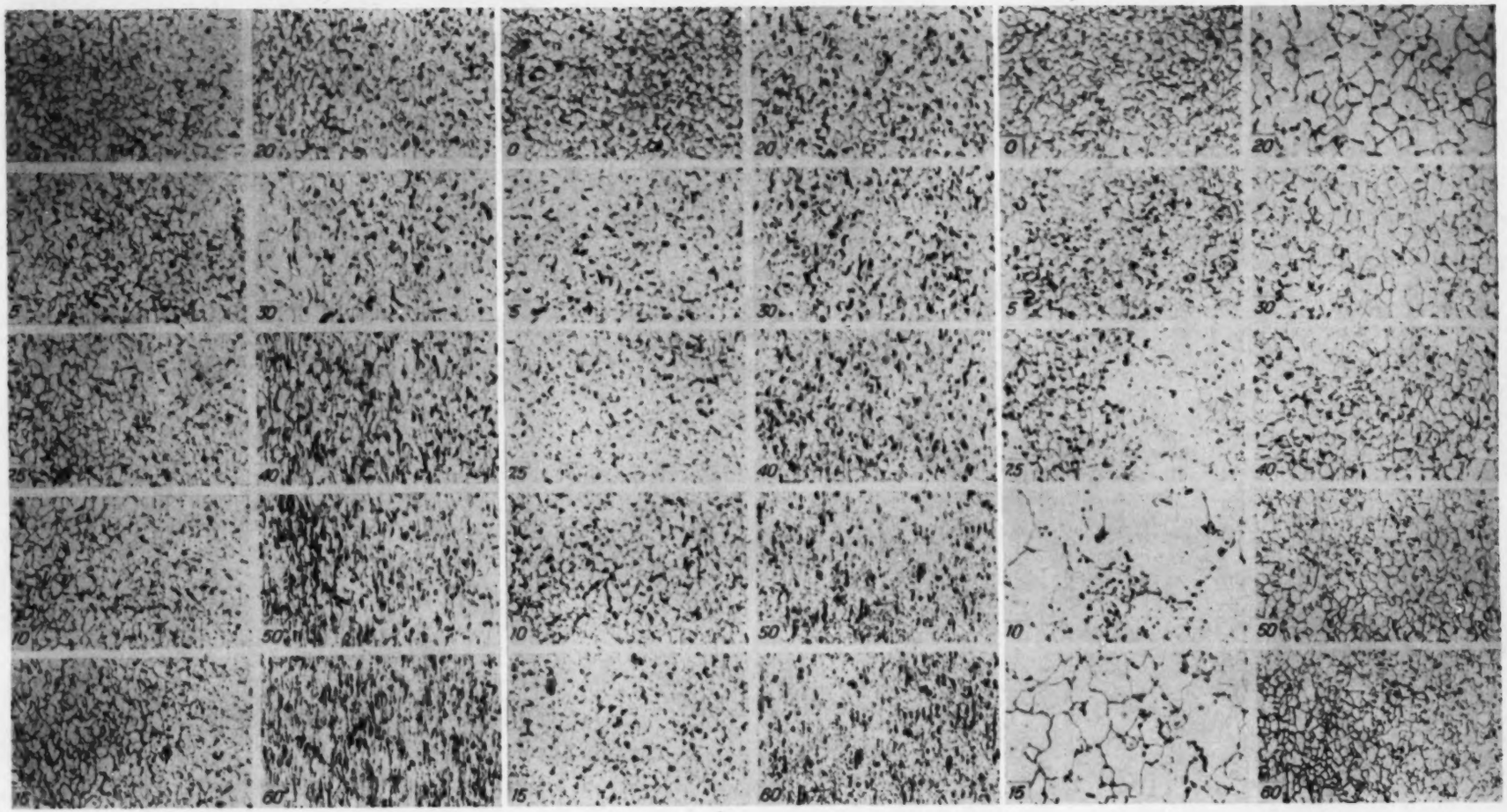
Table 2 gives comparative physical properties of mild steel sheets hot reduced, normalized and box annealed, also cold reduced and box annealed, both as produced and after varying periods of time.

It can be seen that in all cases the normalized and box annealed sheets are harder, stronger, and less ductile than those box annealed only. The cold reduced, box annealed sheets have a greater tendency to age and develop stretcher straining than those normalized and box annealed. The importance of this relationship has been minimized since the development of non-aging sheets and strip which are completely stable against changes in mechanical properties and return of stretcher straining at ordinary temperatures with either processing.

The difference in physical properties and hardness exhibited by normalized as compared to box annealed sheets is not without significance in fabrication. Severe drawing operations of a type that involve uneven de-

Figure 5 — Effect of cold reduction on the Rockwell "B" hardness of mild steel sheets.





6a 6b 6c

Figure 6 — On left is Figure 6a which shows microstructure of mild steel normalized and cold reduced various amounts. Figure 6b in center shows microstructure of mild steel, cold reduced various amounts and box annealed 4 hours at 1100 F and cooled 25 F per hour. On right is shown microstructure of mild steel cold reduced various amounts and box annealed 4 hours at 1350 F and cooled 25 F per hour.

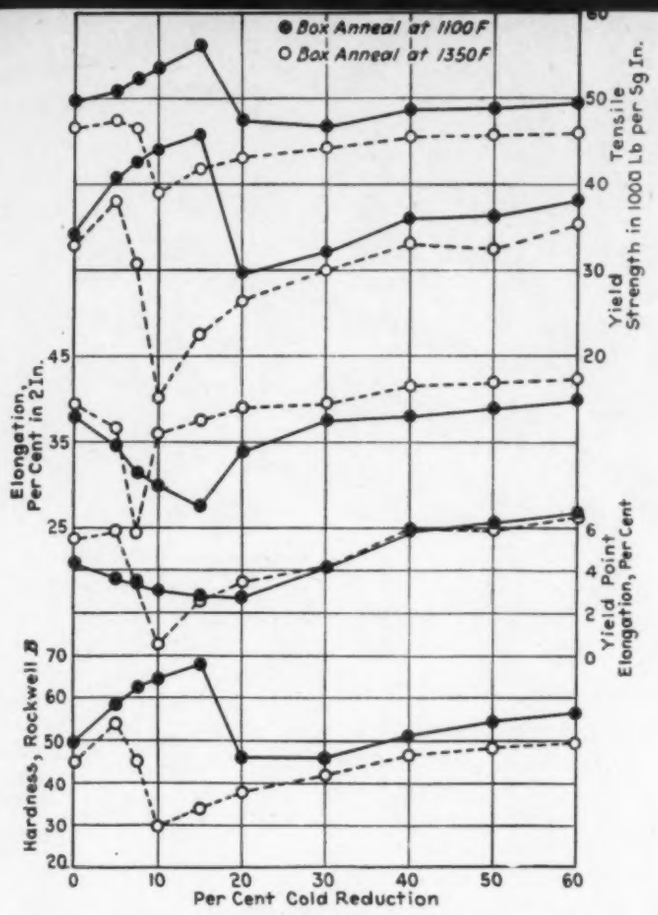

● Box Anneal at 1100 F
○ Box Anneal at 1350 F
Tensile Strength in 1000 Lb per Sq In.
Yield Strength in 1000 Lb per Sq In.
Elongation, Per Cent in 2 In.
Yield Point Elongation, Per Cent
Hardness, Rockwell B
Per Cent Cold Reduction

Figure 7 — Results of physical tests on mild steel cold reduced various amounts and box annealed at 1100 and 1350 F.

formations at different areas of the stamping, or those involving considerable stretching, are best served with box annealed sheets. These sheets have lower yield strength than normalized sheets and therefore the deformation can take place at lower unit stresses under the holddown of the draw die with considerably less tendency to buckle. The tendency to buckle under the holddown generally results in breakage because the press operator increases the holddown pressure to pull out the buckle and makes it more difficult for the metal to flow under the holddown. In addition, box annealed sheets have greater ductility and can be stretched more in drawing.

For balanced draws, a normalized sheet often performs quite satisfactorily provided the radii are generous and the sheet is not stretched too severely. Such draws include table tops, door pans, shell draws and the like. Experience has shown that when breakage is encountered on normalized only sheets in fabrication, the performance can be improved by box annealing after normalizing.

BATCH TYPE ANNEALING EQUIPMENT

The past twenty years have seen many changes in annealing equipment, both of the batch and of the continuous type. The type of box annealing equipment in use in 1927 was essentially the same as that developed many years before. Most of this equipment consisted of a suitable furnace structure large enough to contain a base of cast steel on which the charge was placed, which was then covered with a cast steel cover and sealed with sand. Many of these furnaces were rigged with a charging mechanism of the utmost simplicity, such as grooved channel plates containing cast iron balls about 12 in. in diameter on which the charge was rolled into the furnace by pushing it in with a charging machine. These furnaces were heated by burning coal; temperature control was largely by eye. Figure 9 is typical of that type of equipment.

Weight of the base and cover was just about equal to the weight of the charge, which was about 15 to 20 tons, and the fuel consumption was of the order of 3 million Btu per ton for an annealing temperature of 1400 F. This type of equipment was used both to anneal material directly from the hot mills, such as one-pass black, and also to second box anneal material that had been normalized or full cold rolled. The annealing temperature was different for these purposes, approximately 1400 and 1200 F respectively. Deoxidized material was produced by introducing natural or coke oven gas under the cover to produce a "gas pickle" or "silver finish" depending on whether it was to be applied to unpickled or pickled sheets. Some of these annealing units are still in service; in fact, we still operate 30 furnaces of this type at Middletown, modernized with suitable pyrometer equipment but otherwise still the same. They are used on some of the most difficult grades to anneal that we produce.

As a modification of this type of annealing, continuous box annealing tunnel furnaces were built of a length to hold about 13 to 15 bases and covers, depending on length. These were placed on insulated buggies and pushed through the furnace on a definite cycle. The

TABLE II

Physical Properties of Mild Steel Sheets Tempered 1 Per Cent

Time	Hot-Reduced, Normalized, and Annealed					Cold-Reduced and Annealed				
	Yield strength, psi	Tensile strength, psi	Elongation per cent in 2 in.	Yield point elongation per cent	Rockwell B	Yield strength, psi	Tensile strength, psi	Elongation per cent in 2 in.	Yield point elongation per cent	Rockwell B
Fresh	28,000	49,950	39.9	0.0	47.6	23,770	45,120	42.2	0.0	44.1
1 day	28,400	50,000	38.9	0.2	48.3	24,450	44,750	41.8	0.4	42.6
7 days	31,860	50,470	37.7	0.5	49.4	27,600	44,350	41.0	1.5	42.8
30 days	33,670	50,460	38.3	0.8	50.1	31,210	44,980	40.0	2.5	44.1

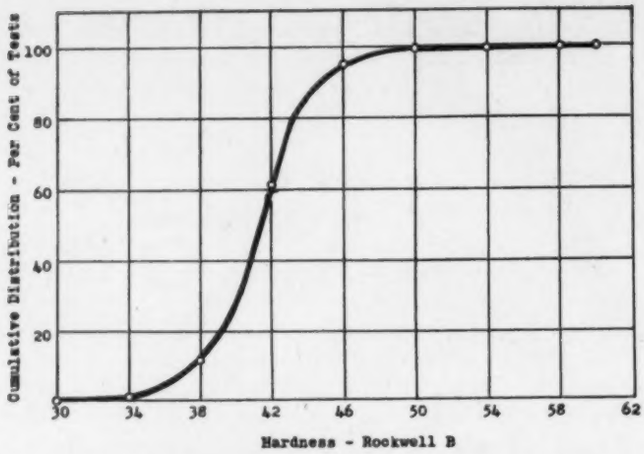


Figure 8 — Plot shows distribution of hardness values for cold reduced, box annealed sheets.

tunnel furnaces were originally built in such a way so that the first six positions from the charging end were preheated by the combustion products from the heating zone, then the next four positions were fired using coal as fuel with the final positions being soaking zone. These furnaces, Figure 10, did a fairly good job on a hand mill product where the control did not have to be too good, but from the standpoint of temperature control of the charge they were poor. Heat was applied to the top by firing over a bridge wall that localized most of the heat in the top of the furnace throughout its entire length. Consequently, the temperature of the top and bottom of the charge got progressively farther apart as the charge progressed through the tunnel until it passed the firing zone. Then the top started to cool off and approach the bottom temperature. In many charges, the temperature of the bottom never exceeded 1100 F. After passing through the furnace the charge was withdrawn and placed on a cooling track adjacent to the furnace. There was no particular fuel economy from this type of furnace, but it did have the advantage of less investment cost as compared to an equal capacity of individual box annealing furnaces. None of these original coal-fired continuous box annealing furnaces remains in operation, all having since been rebuilt.

About 1932, the portable radiant tube type of annealing furnace was introduced and in a relatively short time revolutionized annealing methods in the plants of sheet producers. This type of equipment consists of a number of bases together with a portable furnace that can be moved from one base to another, thus conserving a large part of the heat content of the refractories in the furnace from the previous anneal for use in the next subsequent charge. Figure 11 shows such a unit. Heat application is by means of vertical radiant tubes using gas as a fuel. The advent of this furnace led to the subsequent development of an inner cover fabricated from thin sheet metal; so that the sheets could be annealed without scaling. The combination of improvements resulted in increased production and decreased cost. Similar equipment using horizontal tubes is also available. This type is reputed to be more amenable to close temperature control from top to bottom of a pile of sheets by varying the firing rate in the tubes at various levels. These types of furnaces are both applicable to either cut length or coiled sheets, and the size can be varied at will, depending largely on the lifting capacity of available cranes. They can also be equipped for recirculation if desired. In the early days we operated some furnaces, using recirculation, but abandoned the practice after a short period because of high maintenance cost. It is quite probable that with the improved materials of construction available today, such a practice might be desirable and economic.

Figure 9 — The old style box annealing equipment was made with cast plates and covers.

One problem we have encountered with radiant tube furnaces has to do with the maintenance of the tubes. This has led to the development of the tubeless on-and-off type furnace as shown in Figure 12. We also use this type of annealing equipment to anneal both cut length and coiled sheets. It will be noted that the gas burners are directed down toward the bottom of the stack or coil of sheets which increases the heating rate in a position that ordinarily is the hardest to heat. These units will hold up to 140 tons of cut sheets or 160 tons of coils of 60 in. outside diameter. Fuel rates are averaging around 1.45 million Btu per ton overall with about 1.25 million for coils and 1.75 million for sheets. Total maintenance costs are about the same as with radiant tube furnaces, the cost on tube replacement being spent on extra inner covers that deteriorate more rapidly under direct firing conditions. The direct-fired furnace is as amenable to temperature control as the radiant tube type. It is never out of service for tube replacements and therefore productive capacity is somewhat higher. Any of the various controlled atmosphere gases can be used with these types of furnaces with excellent results. We consider all these on-and-off type furnaces quite suitable for the most exacting type of annealing required in sheet production.

The continuous tunnel type of annealers have been rebuilt to take advantage of developments made in fuel application, light-weight covers and new design of bases. Figure 13 shows a typical tunnel type furnace. These furnaces are capable of being fired throughout the entire length and capacity is dependent on the type material being annealed. The burners are directed downward, firing against a refractory hearth approximately level with the bottom of the charge. They function equally well on cut length or coiled sheets, so long as the loading of individual bases is not changed abruptly. They are controlled in the same manner as individual furnaces,

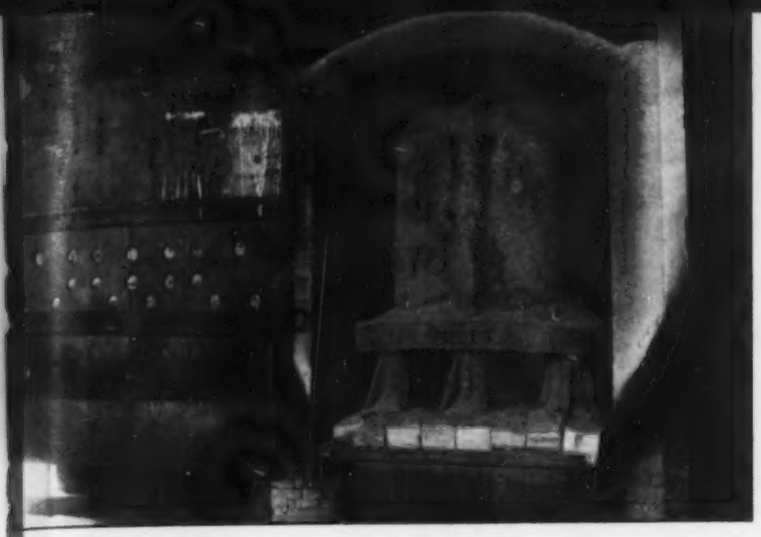


Figure 10 — Temperature control was poor on the continuous tunnel annealer. The discharge end is here shown.

and require approximately the same quantity of fuel. Operating costs are comparable, the chief benefit being somewhat lower investment cost per ton of capacity. The chief drawback is limited flexibility with varying load, and difficulty of operation during periods of low production. Any type of atmosphere control desired can be used with these furnaces, although if a cover springs a leak while it is in the middle zone of the furnace, it is rather difficult to increase the gas flow in that particular charge without increasing it in all other charges in the furnace with the attendant danger of blowing the sand seal. Some of these furnaces have been equipped with individual pressure regulation to each charge to overcome this disadvantage.

As an example of the control that can be attained with this type of unit under relatively constant loading, the spheroidizing of cartridge case steel during the war can be cited. The maximum allowable temperature difference between the hottest and coldest position could not exceed 50 F and the quality of product from these furnaces as compared to that from the individual furnaces was equal or better.

CONTINUOUS ANNEALING EQUIPMENT

Possibly the oldest application of continuous annealing equipment in the manufacture of flat-rolled steel has been in so-called "blue" annealing as applied to the old-fashioned hot rolling facilities for manufacture of heavier gages of sheet and lighter plates. This consisted of a slide-through furnace, open on both ends, through which the rolled product was shoved to equalize the temperature after rolling, or to reheat sufficiently for proper color of oxide when subsequently roller leveled for flatness. The slide-through furnace has now been largely supplanted by the chain-type conveyor furnace for this purpose, but very little material is now processed in this manner.

Not much is known as to when "normalizing" was first applied to the processing of sheet steel, but it probably was begun in the early twenties. The first continuous furnace at The American Rolling Mill Company was installed in 1917 and was originally installed to make "polished sheets" by bluing at a relatively low temperature. These furnaces were of a water-cooled roller type, uninsulated and without cooling hoods and were fired with natural or washed producer gas whichever was available in quantity. It was somewhat later that they were first used for normalizing. When normalizing at 1850 F the fuel consumption was approximately 5.5 million Btu per ton which is considerably more heat energy than is used today in a modern open hearth furnace for melting. The improvement in drawing quality that was obtained by normalizing and box annealing, when compared to that securable by single or double box annealing the hot mill product, was sufficiently great that this method of processing progressed extensively throughout the industry. By 1928 it had become standard practice in processing hot-reduced sheets for the more severe applications.

The original installation was followed with installations of strip normalizing equipment, both at the Ashland division and what later became the Butler division. These strip furnaces were natural gas-fired with water-cooled rollers. The strip furnace at Butler was operated on continuous hot-reduced and cold-reduced coils, while at Ashland sheets were stitched together to make a continuous strip passing through the furnace. These furnaces had relatively short water-cooled cooling zones and the product was characterized by being rather on the stiff side, as normalized, which severely limited applicability of the material for the more severe fabricating requirements. However, by box annealing the sheets after normalizing it was possible to obtain softer material with improved workability for severe draws. Figure 14 shows typical strip annealing furnaces of this era.

The next development in continuous normalizing furnaces took place in the late twenties with the incorporation of "controlled cooling zones" to decrease the rate of transformation of austenite to pearlite, thus securing a larger grain size and softer sheet. This type of normalizing furnace was built with disc, chain and walking beam type of conveyor with considerable de-

Figure 11 — Portable radiant tube type box annealing furnace.

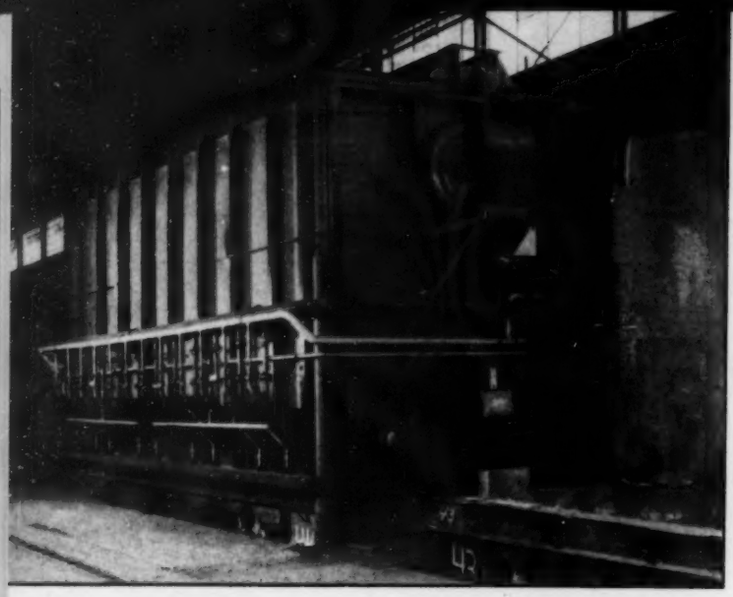


Figure 12 — In the direct-fired box annealing furnace, burners are directed at the bottom of the stack which is normally hardest to heat.

bate as to which was the best in regard to quality of product and cost of normalizing. It was eventually learned that all these types required the use of carrier sheets in order to eliminate the surface defects (pits) encountered on the bottom side of the sheet when carrier sheets were not used. The chain type furnace has been used extensively at Armco since 1928 and it gives a product that is quite satisfactory for severe drawing applications (provided that it is subsequently box annealed if necessary) when a normalized processing is indicated. These furnaces require about 3.5 to 4.0 million Btu per ton.

We have recently installed a hot shaft disc conveyor type normalizer for pack normalizing of sheets, which is considerably more economical than the chain furnace from the standpoint of fuel requirement. This furnace is 105 ft long, takes up to 96 in. width of sheet, and is rated at 9½ tons per hour. The firing zone is 56 ft and the slow cooling zone 49 ft. The average fuel consumption is 2.1 million Btu per ton. Results to date indicate that the quality of product of this furnace is comparable to that obtained from the chain-type of normalizer. However, the use of carrier sheets is still necessary.

We also have another new installation of normalizing equipment that is just now beginning operation. It is a continuous strip type, natural gas-fired with water-cooled roller conveyor, and rated at 10 tons per hour on 48 in. width and is combined with a pickling unit and cut-up line. The conveyor rolls are spaced on 8-ft centers. This unit is shown in Figure 15. While this unit has not been in operation long enough to secure reliable cost data, it would appear that the fuel consumption will be of the order of 1.6 million Btu per ton. This furnace was designed for sectional firing and normally will consist of 130 ft of preheat and heating zone, 95 ft of slow cooling zone, and 75 ft of rapid cooling zone or a total overall length of about 300 ft. It can, however, be operated at a reduced rate to secure slower cooling through the critical transformation. This may be required for extremely severe drawing operations that cannot be served with the somewhat harder sheet obtained at full rated capacity. We believe this furnace line for normalizing represents the best design for quality and economy that we have yet been able to devise. When compared with box annealing cost, however, it still requires 20 to 25 per cent more fuel and 60 per cent more labor. In addition, it will be necessary to box anneal a considerable proportion of the tonnage processed through the normalizer if suitable properties for the more difficult drawing applications are to be attained.

The cost of scale removal or the prevention of scale formation by use of a controlled atmosphere also is a disadvantage accompanying the use of continuous annealing. In the first case scale formed in normalizing is removed by pickling and results in metal loss, while in the latter case investment cost is increased and gas cost for controlled atmosphere is greater than for comparable gas used in box annealing. Maintenance cost in normalizing is also higher than in box annealing.

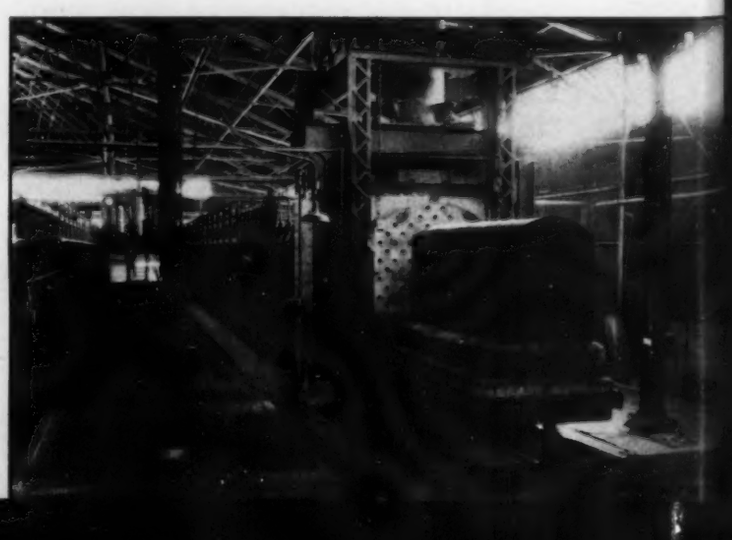
From the standpoint of investment cost, a continuous strip normalizer of 10 tons per hour capacity is equivalent to 8 box annealing furnaces with 20 bases, and costs from 100 per cent and up more than box annealing equipment. Without extenuating circumstances there is little economic motivation to supplant box annealing capacity with normalizing capacity, except in those instances where a normalized sheet contributes improved performance in fabrication, or the nature of the product itself necessitates normalizing.

The American Rolling Mill Company also operates controlled atmosphere normalizers for the processing of special products. These furnaces are either electric or combination gas and electric furnaces. The heat usage on these particular furnaces is somewhat better than that of the gas-fired continuous strip owing to lower heat loss in the combustion products. These furnaces average 1.45 million Btu per ton.

ANNEALING PRACTICES FOR VARIOUS SHEET PRODUCTS

As previously pointed out, the annealing practice used on various sheet and strip products is governed

Figure 13 — Typical continuous tunnel type annealing furnace using light-weight protective cover.



by many factors. In most cases these various factors are interrelated. The Steel Products Manual of The American Iron and Steel Institute for Sheet Steel lists the following grade classifications:

1. Hot rolled sheets.
2. Hot rolled pickled sheets.
3. Cold rolled sheets.
4. Enameling sheets.
5. Galvanized sheets.
6. Long terne sheets.

Each of these classifications is produced in "Commercial Quality" and also in "Drawing Quality."

Hot rolled and hot rolled-pickled sheets of commercial quality are rolled directly to specified thickness on the hot strip mill and are usually shipped without any further annealing treatment. Box annealing is infrequently used as a corrective treatment. Drawing quality in either grade usually requires an annealing treatment to obtain more uniform mechanical properties, and normalizing is generally employed to accomplish this. For very severe applications it may also be necessary to box anneal in addition to normalizing to secure the best mechanical properties for adequate performance in the drawing dies.

Cold rolled commercial quality sheets are almost always box annealed except in thicknesses over 0.125 in. where the problem of physical handling through the cold mill and subsequent processing sometimes makes it more economical to normalize (and box anneal when necessary). Cold rolled drawing quality is practically always box annealed. This annealing process produces the softest and most workable sheet, and when combined with aluminum-killed steel affords the best drawing quality available at the present time. A small quantity of cold rolled drawing quality tonnage is processed by normalizing, but this is a very special requirement mostly in strip widths, where the most uniform properties in all directions are necessary. Such applications include untrimmed shell draws where it is necessary to prevent or minimize "earing."

Enameling sheets are usually normalized both in the commercial quality and in the drawing quality grades. The drawing quality is usually also box annealed. Normalizing is necessary in this sheet classification in order to attain desired uniformity of fabricating characteristics and the optimum behavior in enameling,

Figure 15 — This continuous strip, natural gas-fired, furnace is rated at 10 tons per hour.

especially when the basic material is iron. Many attempts have been made to develop a processing on enameling iron that does not include normalizing, but so far such a treatment has not been applicable to an appreciable tonnage. As this type of material must in many instances withstand repeated heating during the enameling process, it is desirable to minimize directional properties so that warpage is not encountered by relieving harmful internal stresses during the enameling operation.

Most galvanized sheets are produced by cold reduction followed by box annealing and coating. There is also some considerable tonnage that is still being made on hand mills followed by box annealing and coating. If it is desired to coat the cold-reduced sheets without pickling before coating, it is generally necessary to clean the material before box annealing. It might be possible to combine the cleaning operation with a normalizing operation and reach a cost that would compare favorably with cleaning and box annealing performed as separate operations. The majority of galvanized sheet applications can be served equally well with either a normalized or a box annealed basic material. Fabrication of regular galvanized sheets in the past has been limited more by limitations in the adherence of the zinc coating to the steel sheet than in the ductility of the basic material. The American Rolling Mill Company produces a normalized zinc-coated product known as "Zincgrip," which has a coating adherence fully equal to the ductility of the basic material. Our experience has shown that there are applications where the normalized sheet temper has been too hard or too stiff to withstand extremely severe fabrication, even though no peeling of the coating was encountered.

Long terne sheets are usually made from cold-reduced and box-annealed material, both in commercial and drawing quality. However, there is a limited number of applications, particularly in iron sheets, where a normalized and box annealed material functions better.

Figure 14 — These strip annealing furnaces were operated on continuous hot-reduced and cold-reduced coils.

SUMMARY

The preceding discussion has served to indicate the various factors from the quality, economic and produc-

tion standpoint that govern the particular method of annealing utilized to process the various grades of sheet and strip. Even with the most modern equipment now generally in use, the fuel and labor costs for normalizing exceed those of box annealing appreciably. Investment cost for normalizing appears to be at least 100 per cent and up greater per ton of capacity than box annealing. In view of this there appears to be little economic motivation to supplant box annealing equipment with continuous annealing equipment. When normalizing can be combined with other operations, such as cleaning and coating, there is a possibility that some economy in processing cost can be effected. Even so, such a processing results in a product considerably stiffer and less ductile than a box annealed product, which frequently limits its applicability to the less severe types of drawing fabrication.

From the quality aspect, normalized sheets can approach the drawability of cold-reduced box-annealed sheets only when they are box annealed after normalizing, and this is uneconomical except where the nature of the application or the nature of the material itself requires such a heat treatment.

There is little doubt that additional normalizing facilities will be built for sheet and strip processing in those fields where it is economically advantageous to do so by combining operations, or where the grades to be processed require normalizing. It is highly unlikely that normalizing will displace box annealing in the processing of the major tonnages of commodity sheet steel products, such as the hot rolled and cold rolled grades.

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DISCUSSION

PRESENTED BY

A. T. REICHENBACH, Chief Metallurgist, Irvin Works, Carnegie-Illinois Steel Corporation, Dravosburg, Pennsylvania

WILLIAM D. LAMONT, Manager, East Plant, Dominion Foundries and Steel, Ltd., Hamilton, Ontario, Canada

T. F. OLT, Assistant Director, Research Laboratories, American Rolling Mill Company, Middletown, Ohio

W. N. MARBLE, General Annealing Foreman, Jones and Laughlin Steel Corporation, Strip Mill, Pittsburgh, Pennsylvania

C. L. McGRANAHAN, Assistant General Superintendent, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

RAYMOND C. SCHNUTH, Staff Engineer, Steel Furnace Division, Loftus Engineering Corporation, Pittsburgh, Pennsylvania

JOHN R. MURPHY, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

J. M. BENDOT, Chief Engineer, Jessop Steel Company, Washington, Pennsylvania

HENRY EVANS, General Annealing Foreman, Wheeling Steel Corporation, Steubenville Works, Steubenville, Ohio

A. T. Reichenbach: I would like to read a concentrated abstract of what Mr. Olt said, I know that all of you men heard this but I believe it worth while to repeat it: "Continuous annealed sheets are harder than batch annealed sheets. Also this limits continuous annealed sheets for deep drawing applications.

"Secondly, the cost of continuous annealing is greater than batch annealing as such.

"Third, from a cost and quality standpoint there is no reason to replace batch annealing by continuous annealing or normalizing."

However, there are considerable tonnages that are continuous annealed or continuous normalized, and considering some of the disadvantages of continuous annealing such as cost and quality, we might ask, "Why do we do it?" It is necessary to normalize some of our steels, such as low carbon enameling iron. It does not respond to box annealing at temperatures of 1200 or 1300 F, and in order to produce such steels with what we term optimum properties, it then becomes necessary to normalize them or heat treat them at a temperature above the upper critical. Such treatment necessitates normalizing, and of course the cheapest way would be to do it in coils.

Another type of steel that is continuously annealed, that was not touched on this evening, is the silicon bearing or the electrical steels. In past years most of those grades were produced on the hand mills. Costs were extremely high. In recent years the trend has been toward continuous production, that is, cold reducing and continuous annealing in coils. There are two good reasons why that must be done. A number of the customers who produce electrical equipment are buying coils, which means that the electrical properties desired must be attained by heat treatment in coils, therefore they are continuously annealed. Now it would be possible to produce those properties by box annealing, because it has been done in past years, but I do not believe that anybody has yet found a way of box annealing silicon coils at 2000 F.

Another type of continuous annealing which is being practiced to some degree, is the continuous annealing of tinplate. The total percentage of tinplate which is continuously annealed in coils is not large. There are some advantages in doing it that way. I feel that Mr. Olt has very clearly brought out that continuous annealing is practiced in cases where it must be done to develop physical properties or where it can be done in combination with other operations to produce a finished product which is as good or maybe better than the box annealed product.

He touched on galvanizing. It is possible today to

produce galvanized sheets from coils by cold reducing and then putting such coils through a continuous line where they are cleaned, heat treated, coated and sheared or recoiled, as the customer demands may require. That type of processing is supplanting the old hand mill method, which was tremendously costly, and is supplanting the method whereby we took cold reduced sheets and put them through the old type pot, one sheet at a time.

In summarizing, I believe while there are large tonnages of cold rolled sheets that are sold today for the extremely deep formations, they have never been produced from a continuous annealed product. The type of steel being applied for such purposes today is usually a box annealed special killed steel, with physical properties of approximately 40,000 psi ultimate strength, 20,000 psi yield strength, 40 to 45 per cent elongation, and 38 to 42 Rockwell B. We do not know of a continuous type of furnace that will match those properties.

William D. Lamont: Just as a matter of possible interest to this company, I would like to tell you that we in Hamilton, Ontario, are running a continuous annealing furnace. It is a vertical furnace, and we call it tower anneal. It produces ten tons per hour of product of tinplate gage, cold reduced strip. It is heated electrically by resistance units and is run under a DX atmosphere.

We do not call it a normalizing furnace, because we do not think the temperature exceeds 1200 degrees at any time. I think tonight our speaker might have made more clear what he means by "normalizing" and "annealing." I did not quite get what temperature it was assumed that you have to reach before you are normalizing. We do not see any reason for normalizing, because in batch annealing cold reduced strip we do not exceed 1200 degrees, and there is no reason why you should exceed that in a continuous job, and as a matter of fact we do not exceed that. In fact sometimes we do not reach that value.

But eventually all cold reduced strip will be annealed as a continuous process. It seems to me to be the logical step from continuous rolling to continuous annealing, and of course we already have continuous tinning, electrolytically.

We have been running this furnace now for two years, we still do not understand all the mysteries connected with it. We have found that it has specific applications. We cannot get the softer grades from it, but for the harder grades, that is, T-3, T-4 and T-5 it certainly and definitely is applicable. You have to change your tempering practice to suit it, the strip is hard enough that it does not need very much tempering and so you have to bear that in mind and change your temper mill technique.

We have found that on small screw caps and crowned tops for bottles it is better than the batch annealed, we never get into the "dog-eared trouble," that is what we call it in Canada, you may have another term. In the batch annealing we were in and out of that trouble all the time, and with this continuous anneal system we do not get it. We have a very fine grain size, and on definite, specific applications we think the product is better than the batch annealed material.

T. F. Olt: I am reasonably confident that normalizing and even strip annealing at temperatures before the full normalizing temperatures, will never supplant box annealing in sheet products, because of the additional hardness to which Mr. Lamont refers.

I think I did mention that the "normalizing" I was referring to was that involving heating up to about 1750 F, followed by rapid cooling; and that recrystallization could be accomplished at lower temperatures with an increase in Rockwell hardness as compared to normalizing. This implies that when a normalized sheet is too hard, the continuous annealed sheet at less than normalizing temperature is even harder.

I can see very readily where there are many applications in tinplate where the product that Mr. Lamont refers to could be utilized very effectively. I can assure you that we have had plenty of experience in the American Rolling Mill Company to know that we cannot apply sheets, normalized only, extensively in the drawing field. Our Butler division of Armco was predicated originally upon the manufacture of a normalized only sheet for drawing purposes, and much difficulty was encountered in drawing applications. I know when Armco acquired the Butler division, the first equipment installed in that plant was box annealing furnaces to soften up the sheets so they would perform better in drawing. The demand today for soft drawing sheets is much greater than it was in 1927. On the average the severity of drawing applications has increased to the point where it is best served by the very soft type of sheet that Mr. Reichenbach referred to.

W. N. Marble: I had one question to ask, in regard to whether or not Mr. Olt sees any advantages in batch annealing in sheets rather than in coils?

T. F. Olt: We definitely prefer to batch anneal in coils rather than in sheets, and the bulk of our batch annealing of cold rolled grades is performed in coils.

C. L. McGranahan: I would like to ask Mr. Olt, why he prefers annealing in coils rather than sheets?

T. F. Olt: We prefer to anneal in coils as compared to sheets, because we get higher productivity rates on our annealing equipment, and lower costs.

C. L. McGranahan: Are you able to secure equally good physical properties?

T. F. Olt: The answer is yes.

W. N. Marble: I have one more question to ask Mr. Olt, as to whether or not they find longer annealing cycles necessary in getting the proper physical qualities on aluminum killed steel, as compared with open hearth rimmed steel?

T. F. Olt: It takes longer and at higher temperatures in our practice.

Raymond C. Schnuth: Mr. Olt brought up the question of the first continuous sheet normalizing furnace. I think I can answer that. Back in 1919, if I recall, Tom Costello designed this type furnace and it was installed at the former Wheeling Steel Plant at Portsmouth, Ohio. I remember it well, as I started it up. He had the rolls too far apart. When we put the sheets through, and, as they traveled approximately half way through the furnace, they started to sag down between the rolls. However, before they reached the discharge end they were stopped. With the help of a couple of operators, we reached into the furnace with tongs and brought the sheets to the discharge end, then through the leveler. However, at this moment the sheets sheared the leveler shaft, and that, for a couple of days was the

end of the first continuous sheet normalizing furnace. The furnace was of the oil-fired, underfired type.

John R. Murphy: Mr. Olt states a definite preference for annealing in coils, and at the same time mentions equal physical properties from that material annealed in coils as compared with sheets. Does he find it equally as easy to control the per cent skin rolled temper in coils as he does in sheets?

T. F. Olt: That is a question that I do not know very well how to answer. I presume, though, that they do control temper pretty well. Our general practice is to anneal and temper everything in coils that we possibly can, and if it has to be shipped as sheet, it is cut up as a final operation. We use the conventional methods of checking temper on the temper mill. They have a scribe which scratches a fixed length on the material which they measure again after it gets through the mill.

C. L. McGranahan: Do you have any more complaints from the customer on the amount of rejects on shipments in coil rather than in sheets? We all realize that if you have 5 or 10 per cent rejects in a coil you are going to ship it, because it would not be economical to reject it or cut it in sheet size. In general, is your amount of rejects in coils about the same as you have in sheets?

T. F. Olt: No, we have rejects when we make sheets which cannot be removed when coils are shipped. Nowadays I think the customers are very cooperative and the complaints on coil shipments are not very great.

J. M. Bendot: I would like to ask Mr. Olt how he compares his cost of batch annealing with strip annealing of continuous strip on the low carbon grades, you favor the batch annealing, do you not?

T. F. Olt: Very much so.

J. M. Bendot: What is your opinion on the stainless grades?

T. F. Olt: As a general rule we do not batch anneal any stainless grades. They are all either strip annealed or annealed in a muffle furnace.

Henry Evans: I would like to ask Mr. Olt how his yield on coil annealed compares with batch flat annealed?

T. F. Olt: I suspect that the yields are better on the coils than they are on sheets, although I could not say that definitely. I do not think we would prefer to anneal in coils as compared to sheets if the yield was reduced appreciably.

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IN EACH AND EVERY ISSUE

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC. OF

IRON AND STEEL ENGINEER

(Required by the Acts of Congress of August 24, 1912, March 3, 1933 and July 2, 1946)

Name of Publication: *Iron and Steel Engineer*, published monthly at Pittsburgh, Pennsylvania. (Report of October 1, 1946.)

State of Pennsylvania
County of Allegheny

Before me, a notary public in and for the State and county aforesaid, personally appeared T. J. Ess, who, having been duly sworn according to law, deposes and says that he is the editor of the *Iron and Steel Engineer* and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933 and July 2, 1946, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher: Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh Pennsylvania.
Editor: T. J. Ess, 1010 Empire Building, Pittsburgh. Pennsylvania.
Managing Editor: None.
Business Manager: None.

2. That the owner is: Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh, Pennsylvania.

No stockholders.

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T. J. ESS, Editor.

Sworn to and subscribed before me this 19th day of September, 1947.

G. WILLIAM JONES, Jr., Notary Public.

(My commission expires February 9, 1951.)

POWER CYCLES AND POWER GENERATING EQUIPMENT

. . . . in attempting to attain higher thermal efficiencies, power plant designers are ever raising the limits on temperature and pressure . . . .

By A. R. SMITH
Managing Engineer
Turbine-Generator Division
General Electric Company
Schenectady, New York

▲ THE hydraulic turbine has not changed much in many years. The top capacity is in the order of 100,000 kilowatts, the over-all efficiency is about 90 per cent. In this country, roughly one-third of the generating capacity is hydraulic, and two-thirds steam, and usually one-third of the kilowatt hours is generated by the hydraulic power plants. The Francis turbine is a moderate head turbine, the Kaplan wheel is a high head turbine. The Pelton wheel which is relatively new, is a low head and variable pitch.

I was connected to some extent with the Passamaquoddy development, or attempted development, in which they expected to develop, with Kaplan wheels, from the tides some 350,000 hp from tides. The spring tide was 26 feet, and the neap tide 14 feet, but they had to take care of 350,000 second feet which is a flow of water so great that you could see the water going down hill from one bay to another. The promoter of that development is dead and I predict you will never see a real tidal development.

The steam turbine is the main source of energy and is going to be for some time to come. Pressures and temperatures are increasing, but the steam engineers, hearing of the gas turbine, want to go to higher and higher temperatures, not knowing just what it means. One turbine we have on order is 100,000 kilowatts, 3600 rpm, 1500 psi, 1050 F and that will have an overall net thermal efficiency of 10,000 Btu per kwhr-coal to kw output.

We have another one on order which is 150,000 kilowatts, 1800 rpm, 2000 psi, 1050 F initial, 1000 F reheat, and that is supposed to have a net output of 9200 Btu, or, 37 per cent thermal efficiency.

Figure 1 shows the 100,000 kilowatt, 1500 psi, 1050 F machine, which has a three flow exhaust. That will be the first machine of its kind in this country.

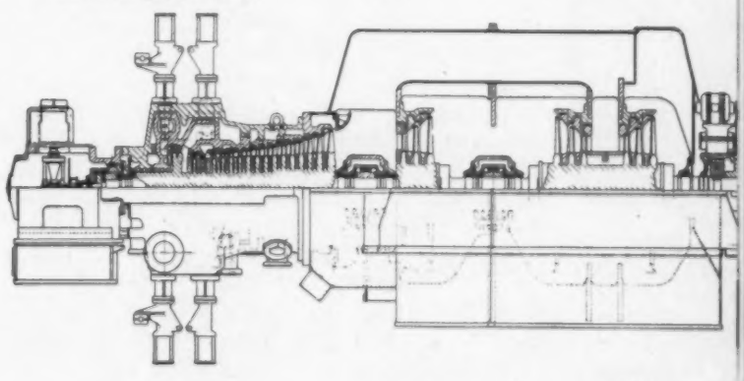
Figure 2 shows a unit in the Ford plant. It is 110,000 kilowatts, steeple compound, two 55,000 kilowatt generators put in the space that formerly was occupied by a 12,500 kilowatt machine. It is the most concentrated power plant in the world, and the cleanest one.

The first machine was put in service in the summer of 1931, fifteen years ago, and it has never been opened for inspection. Our rules are that a new machine should be opened in a year and if it looks good, then you can take a two year period. This machine has been running for fifteen years without any apparent loss in efficiency. The second machine has been running for ten years, the third machine five years, and none of the three has ever been opened.

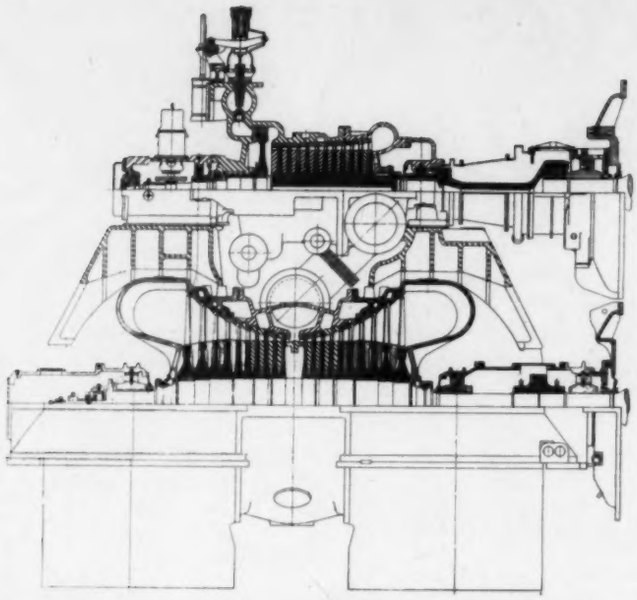
Figure 3 shows the exterior view of those machines.

Figure 4 is an artist's conception of how a turbine should look, and I think it will actually look that way. It does not have all the finishing touches yet but that machine at Consolidated Edison in New York, has a

Sectional view of 100,000 kw, 1500 psi, 1050 F, 3600 rpm turbine generator.



Presented before AISE Chicago District Section Meeting, November 13, 1946



This 110,000 kw, 1800 rpm, steeple compound turbine generator located in the Ford plant, is one of the most concentrated power plants in the world.

steam flow of 2,000,000 pounds an hour, far in excess of any turbine in the world.

METALS

We used to think of metals as having just a few characteristics: ductility, elastic limit, and ultimate strength. The test could be made in a few minutes. Now with hot metals, that is not true. We do not think of ductility or elastic limit in the same sense. We have hot rupture, hot creep, corrosion fatigue, explosion, grain size. By "explosion" I mean the act of breaking a piece of metal in three dimensions.

The old method of testing rupture or ductility or elastic limit was usually only in one dimension. You pulled it and it became tinner and weaker and finally broke. When you spin a rotor in a vacuum pit, it tries to strain in three dimensions and each one is opposing the other so that it finally explodes. We have five such explosion pits for the study of wheels and rotors. We have 200 bars in continuous test for hot rupture, 68 bars for hot creep, Figure 5, 12 bars for hot fatigue, Figure 6. We had 4 bars under stress and under temperature of 842 degrees F for 12 years so we could find out if the creep curve changed its shape.

Retaining rings on our generators have an elastic limit at room temperature of 100,000 psi. Buckets must stand 1200 F at 30,000 psi stress for 1000 hours and on the gas turbine for airplanes, buckets must stand 1500 F at 25,000 psi for 100 hours.

Due to the activity of the steam engineers in high temperatures, we ordered 6 rotor forgings for turbines: carbon molybdenum, carbon nickel vanadium, carbon chrome vanadium, carbon chrome 12 tungsten vanadium, and carbon chrome 15 cobalt tungsten vanadium. These forgings will be cut up in pieces to determine their machining characteristics, their grain structure, and so forth.

We have two turbine castings in our shop, one of carbon molybdenum vanadium, and one 18-8 stabilized with columbium which will be tested and cut up so that we are prepared to supply a steam turbine that anybody wants at the highest possible temperature.

INTEGRATED TURBINE UNIT

For some time, the turbine designer has been a little lax in giving the power plant designer all he deserved. The turbine generator has the longest shipping promise and it is therefore ordered first. Everyone has been told the kind of a machine he is going to get, so the power plant designer locates the turbine, puts the condenser underneath, and then he distributes the auxiliaries around the station and pipes them. This is not the way to build a machine. The diesel engineer has always had the advantage of us in the sense that when you bought a machine, you received a complete unit.

Figure 7 shows an integrated plant for the Ford Company at Northville rated at 750 kilowatts. That machine was built in two parts; the turbine generator and the condenser is one element; and the boiler and the integrated auxiliaries are the other element.

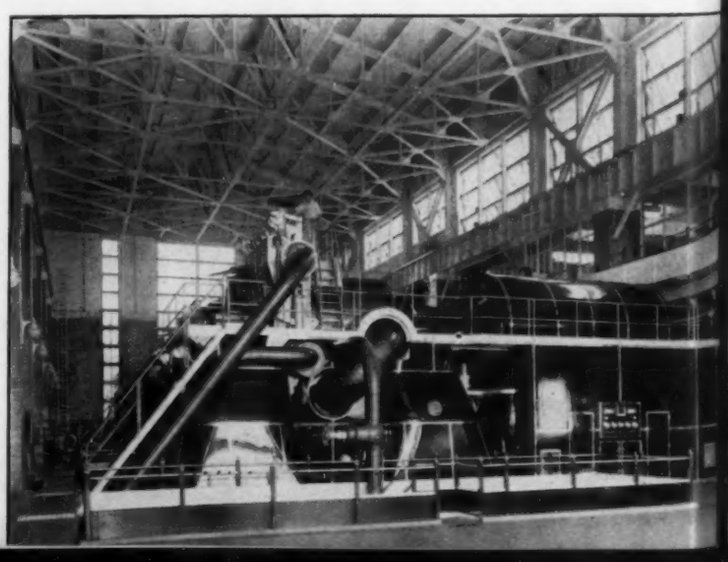
The next attempt at an integrated unit was the destroyer escort, see Figure 8, which is a small destroyer, having a rating of 6000 hp in each unit, (two propellers) in which the turbine and the generator are on the condenser. Seven hundred of these units were built.

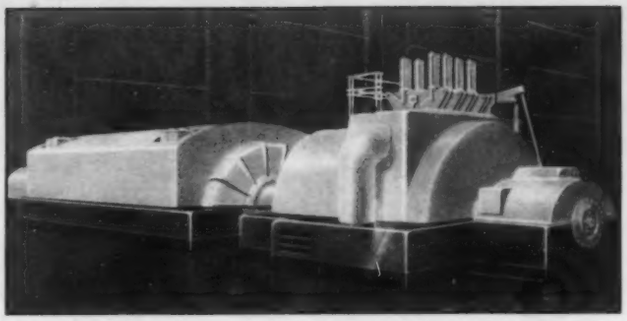
Then we studied the idea of making an integrated steam plant of 50,000 kilowatts. Figure 9 shows the integrated unit. The heaters are hung right from the turbine. There is only one operating floor. The front operating position is as you see it there. Everything is operated from that location.

Figure 10 shows another view. The operating passages make everything accessible. It takes up very much less room. It is the way a power plant really ought to be built.

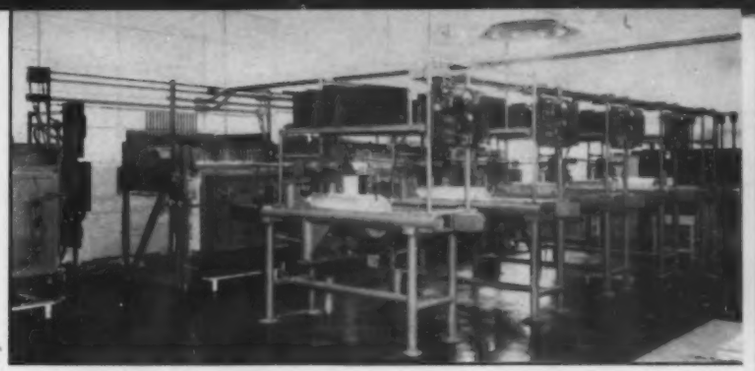
Figure 11 illustrates the idea of the destroyer escort, a turbine and generator on the condenser, for the condenser makes the best foundation. We have had a great deal of trouble with concrete and steel foundations. We have found that concrete foundations grow; and that subject to the opening of doors steel structures are

Exterior view of 110,000 kw Ford unit.





Artist's view of 65,000 kw, Consolidated Edison Company of New York's topping, turbine generator.



The creep furnaces in the hot metals test laboratory obtain data for metal design at high temperatures.

even worse. The best foundation is the condenser with the air outlets on either side so as to hold a uniform temperature in the walls. That will be built very shortly.

Both of these schemes, however, have the one drawback. They are so different from the general scheme and conception of turbine rooms that one ought to put them in a new plant. They do not fit in so well in an existing plant.

OUTDOOR PLANTS

The outdoor plant was really started by the steel companies many years ago. They used to put their brick boilers outdoors. We built such a plant as that in Chile for the Bethlehem Steel Company where building material was expensive and where the climate was quite satisfactory and the boilers were put out of doors facing into the turbine room.

In Schenectady in 1930, we built the first outdoor steam and mercury plant.

See Figure 12. This plant was built as an integrated unit. We did not use any brick in the walls. It was a piece of machinery from top to bottom. I have had a lot of experience in trying to build power plants for industry and I have found that those that I designed for expansion never expanded, and those that I thought were complete in the beginning always expanded, so it is difficult to outguess them.

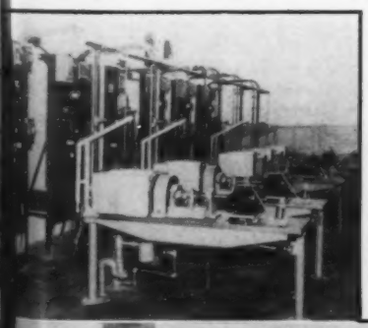
In this plant the pilasters are made out of $\frac{3}{8}$ in. steel. The pilaster is one piece, and the girder sets on the gusset at either end and is welded. The steel sash windows are welded in place and the building is done. If you want to take the end out of it, you simply burn these welded joints and move it where you please and reweld. It is inexpensive.

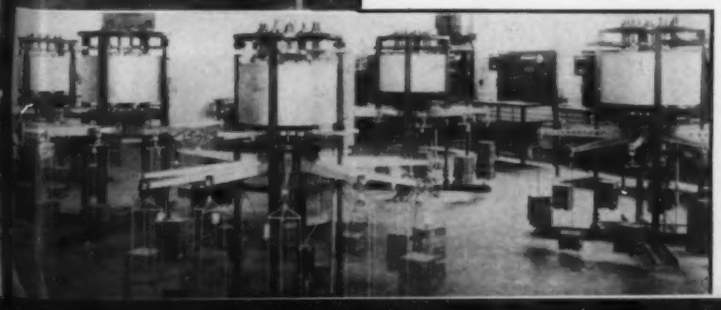
Electric Bond and Share are introducing the outdoor plant quite extensively. The new Sewani plant of Public Service in New Jersey is going to have the boilers out of doors.

THE MERCURY PLANT

The thermal efficiency of the mercury plant is 40 per cent. It is ideal as a topping unit.

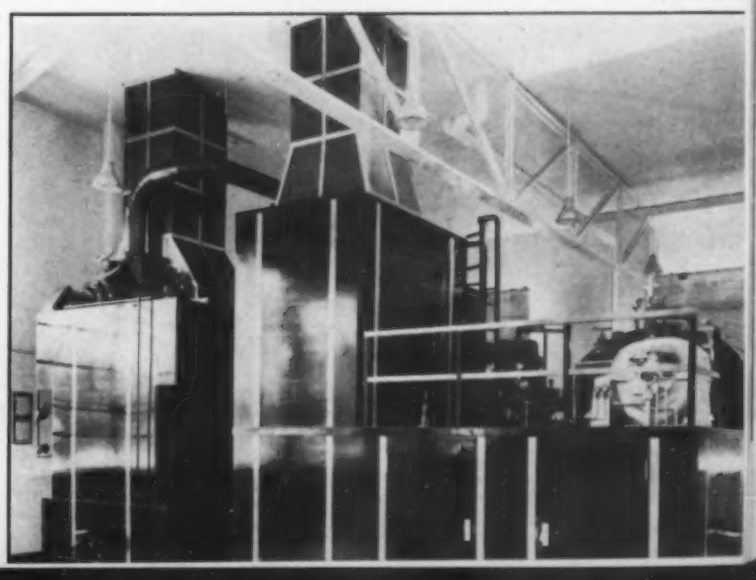
We do not open these turbines any more. The turbines operated in the order of 975 F in the front end and 500 F in the exhaust and went out of shape. When we opened the turbines, we found we had to remachine the flanges, so we decided that we would just let them go the way they were. None have been opened up in several years. One of the objections to the mercury cycle was the fact that if you got a leak, you lost mercury and that meant money; and while the depreciation on mercury has been only in the order of $2\frac{1}{2}$ per cent on the three plants, there is reaction against buying any new mercury. So we made some experiments of putting some blind tubes in several places in a mercury boiler which stuck out in the furnace some eight inches. We put thermocouples in them to find out how hot they became and how long they lasted. We

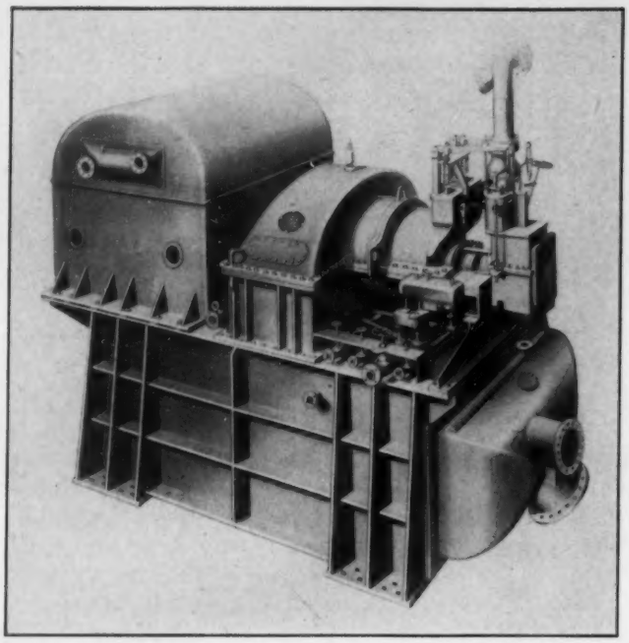




Fatigue rupture furnaces in the hot metals tests laboratory.

This 750 kw package unit in the Ford plant is built in two parts.





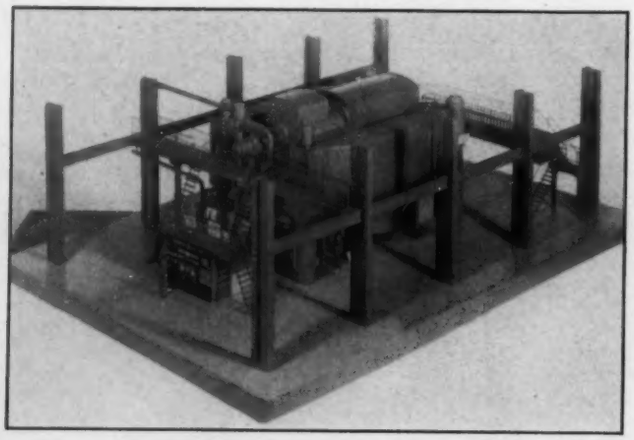
This model of a turbine generator was designed for a destroyer escort.

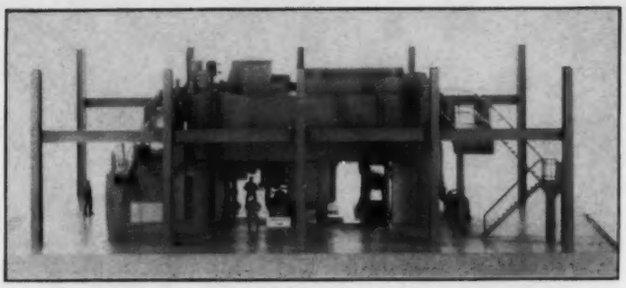
found that tubes so exposed with no circulation and no protection from the adjacent tubes would last 12 or 15 hours in the hottest part of the furnace. We made up an auto-switchboard and put a thermocouple on every one of the 790 boiler tubes in Kearny; thus the temperature is read every hour for each tube and is calibrated every 10 or 12 readings by reading the temperature of the mercury. The setup required no attention. If a tube ran over the proper temperature, it rang a bell and you had ten hours to shut down and still not lose mercury.

THE OIL-FIRED GAS TURBINE

Much has been said about the oil-fired gas turbine. There are no coal-fired gas turbines yet. Some people from Switzerland told me recently they had given up the coal-fired gas turbine, and outside of the oil refinery or Houdry process, there are only about half a dozen gas turbines in operation on regular power cycles.

This model of an integrated unit with side condenser has never been built.





The integrated unit model was based on a 50,000 kw prototype.

Brown Bovri has a 4000 hp unit in Hungary. Escherwyss has a 2000 kw very complicated closed cycle in Switzerland. Elliott has one in test and Allis-Chalmers has one. We did a lot of development on the gas turbine for the airplane, and have just recently turned our attention to a long-lived gas turbine for commercial service.

Figure 13 shows a 4500 hp gas turbine oil-fired for a locomotive. This unit, as far as we can figure, will be in operation in the early spring and when it has proven itself out, it will go in a locomotive.

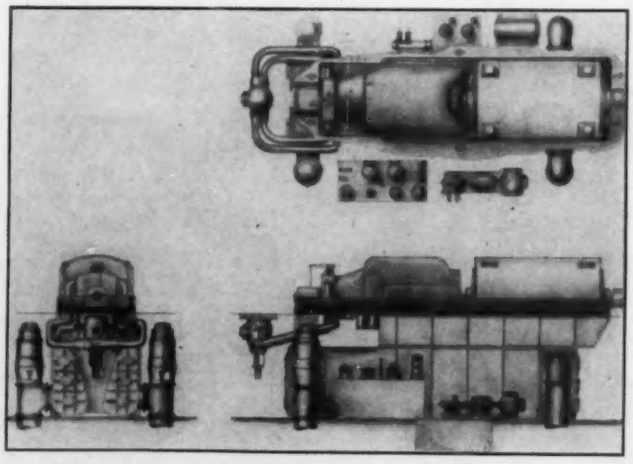
As far as coal-fired gas turbines are concerned, we had two things in mind. One was to make a pressure gas producer which has never been made before, operating at about 100 psi, so that there is low velocity because of the pressure and low velocity because one puts in half the air one needs for combustion and which would leave the ash in the fuel bed. We started the Battelle Memorial Institute on that development several years ago. It is pretty well completed and it now appears that the attention the fuel bed needs is too much to make it a good locomotive unit.

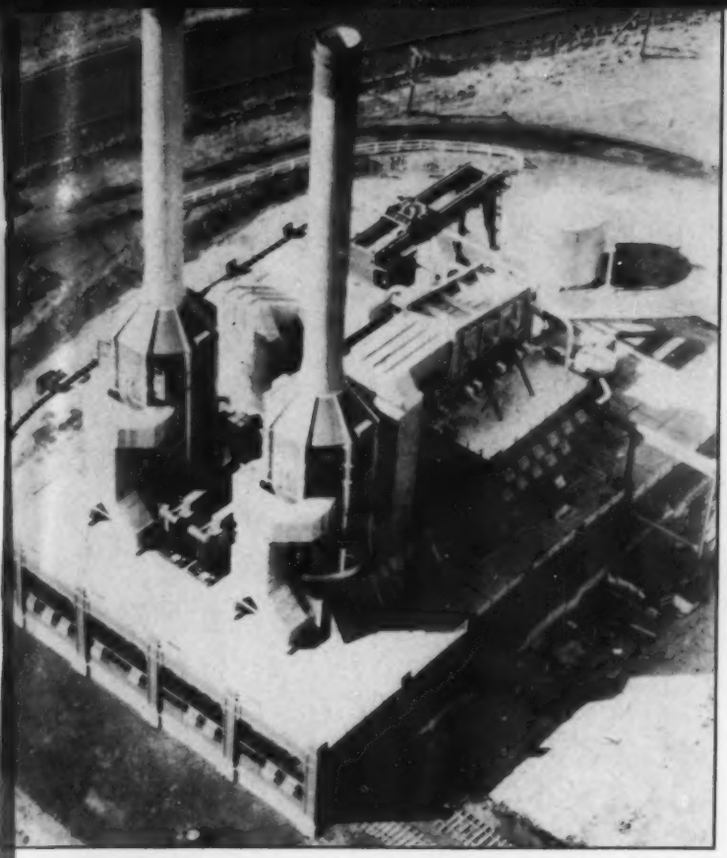
The other system we have started on is fine pulverization of coal to such a degree that it follows the air and does not erode the buckets. Professor Yellott is working along the same line for the Bituminous Coal Research group.

STEAM LOCOMOTIVES

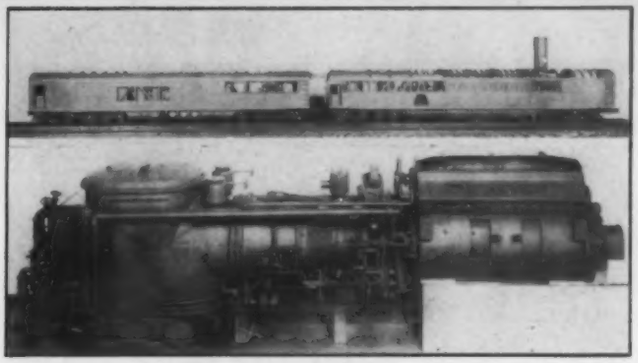
The Baldwin-Westinghouse locomotive, 6000 hp with the conventional five tube boiler operating at 300 psi

This model shows a turbine and generator mounted on the condenser.





The Schenectady plant is an outdoor steam and mercury plant.



This Navy mobile power plant is rated 10,000 kw.

and 750 F, with the turbine geared to the drivers, has been in operation for some time. I believe it has covered some 10,000 miles. The London, Midland and Scottish Railroad in England did that same thing in 1937, only it was 2000 hp unit. They built brother locomotives, one cylinder-driven and one turbine-driven, and they ran the same route from London to Glasgow. I rode in a dynamometer car in 1937 to Newcastle and up to this day, they cannot find out whether it is any better than the cylinder locomotive. It has somewhat the same characteristics and does not have a better fuel rate.

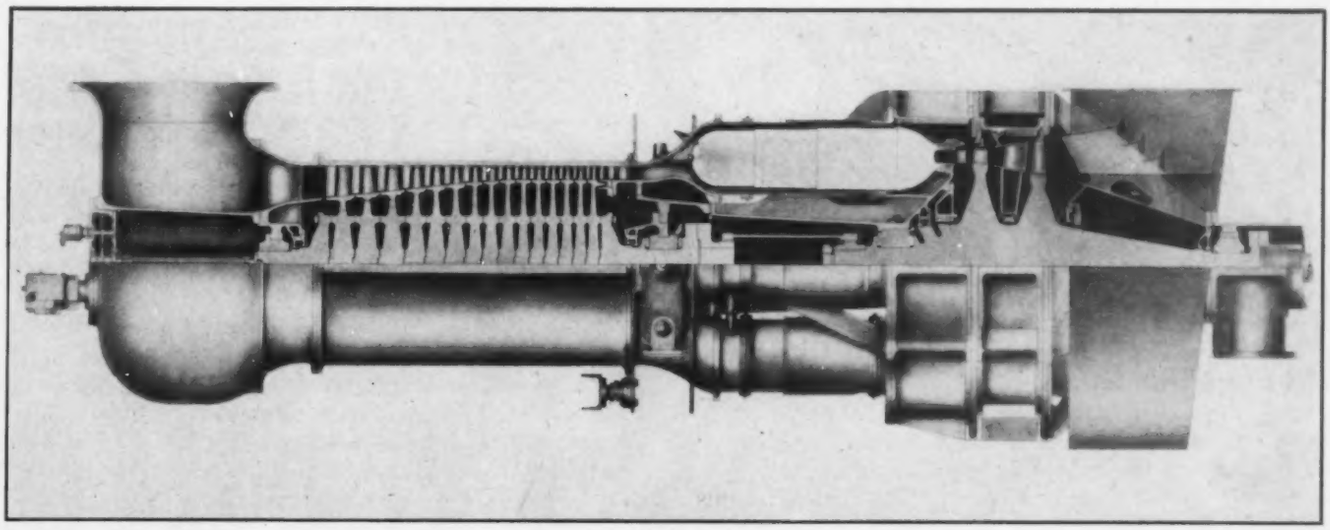
The C & O has placed an order with Baldwin-Westinghouse for a 4000 hp unit with the conventional fire tube boiler and electric drive. The Pennsylvania Railroad is contemplating a 9000 hp mechanically driven, conventional fire tube boiler. The Eastern Railroad Committee has sponsored a development for 600 psi, 850 F locomotive of 6400 hp. The boiler has been built by the Babcock & Wilcox Company. The first one was a disappointment, the second one has been very successful. In the combustion chamber, the ash is in liquid form at high temperature and then cold air or cold gases of combustion or exhaust steam is introduced in the second passage which puts this ash, which is still in suspension, in a powdered form. It can run quite indefinitely without serious slagging deposits.

MOBILE PLANTS

We built four floating power plants, of 30,000 kilowatts. One is in Jacksonville, one is in Philadelphia being repaired, one is in Manila, and one is on its way to Puerto Rico. They were ordered by the Army and could operate at 50 or 60 cycles for use in Europe. They have been successful. It is a good way to make a mobile power plant.

Prior to that, the Navy ordered two mobile power plants. They wanted them on rails. See Figure 14. They were 10,000 kilowatts, and have operated very well. One is in Philadelphia. The turbine car is on the left and it has a six axle truck, for the tremendous load. That truck is probably the biggest truck that has ever

This 4500 hp, oil-fired, gas turbine unit was designed for locomotive use.



Forty 3000 kw mobile units were built for Russia.

been designed. Ten axles support 60,000 pounds an axle for a total of 600,000 pounds for the car.

We built 40- 3000 kilowatt mobile units for Russia and 21- 1000 kilowatt units, Figure 15.

DIESEL PLANTS

The large diesel power generating units in this country constitute about two per cent of the total capacity. The steam and hydraulic plants are somewhere on the order of 50,000,000 kilowatts, and the diesel plant capacity is 1,000,000 kw. The average thermal efficiency is 27 per cent and as near as I can make out, the top net is 32 per cent. There has been a desire on the part of many of the designers to supercharge the diesel so as to cut down the weight or increase the efficiency or both, and claims have been made that they might reach 40 per cent. One way of operating is to use the Pescara free piston engine which gets rid of the bulky crankshaft. There is one unit operating in France in Lyons and there is a free piston engine operated by the General Machinery Corporation in Hamilton, Ohio, and there is another practically ready which was built by Baldwin.

DISCUSSION

PRESENTED BY

H. R. MIDDLEBROOK, Assistant Division Superintendent, Power and Fuel, Gary Steel Works, Carnegie-Illinois Steel Corporation, Gary, Indiana

A. R. SMITH, Managing Engineer, Turbine-Generator Division, General Electric Company, Schenectady, New York

W. P. PALMER, Superintendent, Power Production Division, South Works, Carnegie-Illinois Steel Corporation, Chicago, Illinois

CHARLES R. DIETZ, General Foreman, Electric and Power Departments, Inland Steel Company, East Chicago, Indiana

JAMES HARTNEY, Power and Fuel Engineer, Carnegie-Illinois Steel Corporation, South Works, Chicago, Illinois

J. S. TUITE, Superintendent of Power, Youngstown Sheet and Tube Company, Indiana Harbor Works, East Chicago, Indiana

W. J. TUNNY, Assistant Electrical Engineer, Youngstown Sheet and Tube Company, East Chicago, Indiana

GORDON FOX, Vice President, Freyn Engineering Company, Chicago, Illinois

V. E. SCHLOSSBERG, Assistant Superintendent, Electric and Power Departments, Inland Steel Company, East Chicago, Indiana

L. A. TERRY, Superintendent, Power and Electric Department, National Tube Company, Gary, Indiana

H. R. Middlebrook: There is one thing about which I would like to know, and that is the Pescara free piston engine. Could you describe it briefly, Mr. Smith?

A. R. Smith: Pescara is an Italian who developed a diesel engine with two pistons in the middle, and a common combustion chamber blowing out the pistons at either end. On the other end of each piston was an air compressor so that you did not have to transmit any power through a crankshaft. I saw one in this country as a street surfacing compressor. It looked like an ideal machine for compressing air. There was some synchronizing which had to be done so they introduced a small crankshaft. They did not know how big it ought to be, so they made it a little stronger than calculated. Then a designer from the United States suggested that should a compressor valve get stuck on one end there would not be anything to stop this piston. In other words, you had a gun, the piston would go

right on out. Then they put all of the compressor on one end which meant of course you had to transmit half the power through what was equivalent to a crankshaft. It is still a clever machine and the idea is that it gets to be a combustion chamber which generally stands vertically. A machine may consist of a dozen cylinder heads and all operate independently. You can shut them down one at a time and the exhaust from these go through a common gas turbine. It is the same as if you had a dozen small steam boilers and one steam turbine. How it is going to turn out, I do not know. It has been worked on for 15 years.

W. P. Palmer: I would like to ask Mr. Smith about these high pressure temperature turbines. I noticed he talked about the Ford unit not being down for overhaul for several years. I know it used to be the utility practice to take each unit out of service every year for overhaul and inspection, but in the steel business we just do not have spare units. We run everything most of the time at overload, and at the present time each of our three turbogenerators are overhauled about every two years. We take them down and find on inspection that there is not too much the matter with them. We can not help but agree with your statement that the parts do get warped and sooner or later we have a hard time getting them back together.

On these higher pressure and temperature units, would it be feasible to say that these units could run three years without too much trouble?

I also have another question on regulation. At our plant we happen to have a 30-ton electric furnace and two 60-ton units. That is the rated capacity, but whenever we install equipment like that we always exceed the rated capacity. There are times when the electric furnaces will be taken off all at once and our electric load will drop 30,000 to 35,000 kilowatts at once. Now on a 50,000 kw unit with this high pressure and temperature, what effect would such a swing in load have on these units? In other words are they built ruggedly enough to adequately withstand the swinging loads that we have?

A. R. Smith: I think that we will be able to build high pressure, high temperature turbines with the same margin of safety that we used to build for low pressure, low temperature. We are a great deal smarter than we used to be and I believe you can run three years without inspection. It seems to me that if you buy a turbine substantially like what other people have purchased and they have run them and found upon opening that nothing was wrong, you can run a longer time. We have some turbines out, with as many as 20 of them substantially alike. We have opened them up and found practically nothing.

A customer who was in the other day said, "I cannot take the turbine off." On checking up, there were several turbines just like this that looked all right when they were opened, and he was told that he could run three years and be safe.

As to the change in load, I cannot tell you about that. The WR^2 factor is puzzling. I have been told that you just do not make any more headway because you have a low speed, heavy machine as far as fluctuating loads are concerned, you get substantially the same result. Because of the higher temperature, the greater the change from no load to full load or from no load to standstill, and that is always harder to handle. I do not think the pressure makes any difference.

Charles R. Dietz: Mr. Smith in talking about concrete and steel foundations stated they used a condenser for a foundation. I would like to ask if you have a condenser foundation and your machine is set on it for a certain level, what takes place with the water temperature changes at certain times during the year, for example, in the summer months when it is high? Also what happens to the turbine that is non-condensing when the condenser loses water and becomes overheated?

A. R. Smith: We had a concrete foundation in Baltimore under a topping unit that grew a number of mills every year and no one has ever found out why. We had one in Philadelphia that did the same thing. When you talk about the difference in temperature of water between winter and summer, you are only talking about 60 degrees and the whole thing goes up and down from end to end about the same, so the only difference from end to end is the temperature rise of the water which usually is in the order of 15 degrees or so. We just do not recognize the loss of water any more. That is an old time fault. We make no provision against the loss of water. We used to put in valves so you could run non-condensing. The modern turbine must not be run non-condensing, regardless of whether on a condenser or not. The first thing you do is get a good circulating water system which can always be done.

James Hartney: Based on laboratory tests and other observations you have made on metals under high temperature, I would like to have your idea of steam temperatures that would not be considered pioneering any more?

A. R. Smith: I would say for a moderately large turbine, I do not think 1000 F is pioneering; 1050 is still pioneering. It looks like the materials are going to run into more money than justified by the unproved heat cycle. You know the trouble we had with graphitization of pipe at 900 F. The country is full of 900 F plants. Nobody ever heard of graphitization and now they are faced with costly changes and frequent tests. What is in store for us on 1050? I do not know. You may get away with it and you may have trouble. I think that last 50 degrees is about the toughest thing you can handle. On these high chrome-nickel alloys we can go to 1100, but they are very expensive.

J. S. Tuite: We have one topping unit in Indiana Harbor, and practically the only reason we take that machine out for periodic overhauling is to check the alignment of the bearing. The concrete foundation has shown a definite change on each inspection and whether that will continue to occur, I have no way of determining.

In regard to outdoor power plants, I am wondering whether they would be practical for steel mills due to the more or less dirty surroundings characteristic of steel plants, blast furnaces and such?

A. R. Smith: Yes, I think they are applicable to steel mills. The turbine generator is all closed anyway. The principal trouble occurs when you are overhauling a turbine generator. We built our plant in Schenectady in one of the coldest winters we ever had and the most trouble some think was the wind, not the cold or the heat or the rain. The wind disturbs a fellow who is

trying to make accurate measurements, you have to put up a barrier.

W. J. Tunny: One question in which I am interested, is that you often see power plants that have a taper cut on the top of the stacks. I appreciate they have more area by this design. However, when the wind changes and the wind goes down the stack, what happens to the efficiency?

A. R. Smith: I do not think the wind makes any difference. As a matter of fact, we do not depend on thermal effect for draft. It is not worth enough and we depend on induced draft fans or blowers.

Gordon Fox: Mr. Smith has indicated the many ramifications to the subject of power plant engineering and some of the approaches being made to the attainment of higher efficiencies. The substantial amount of thought and research directed to the several aspects of the problem would seem to indicate that we may expect considerable change and improvement.

On the other hand, Mr. Smith spoke of a "packaged power plant." This would seem to require a substantial measure of standardization. I would ask the question whether the "packaged power plant" is sufficiently flexible to be adapted to the variety of local conditions which commonly affect the designs for industrial power stations and also whether the "packaged power plant" idea is entirely compatible with the trend toward new and better methods.

A. R. Smith: Speaking of local conditions, you are quite right. One of the most difficult things to standardize on is the circulating water and I do not think we are going to make much headway with that. When you talk about a topping unit like the mercury, then you can put it right out there on the ground as a package plant and run the steam produced right in to the existing headers. We are not making much headway on standardization of steam turbines, but that is the way to build turbines in a standard form. The old trolley car to me was a horrible example. Every railway manager had a special problem in his city. His public was different than in other cities and he had to put on another seat to serve another passenger. When they got through with the trolley car with all its independent designs, it was the poorest piece of machinery that ever was perpetrated on the public.

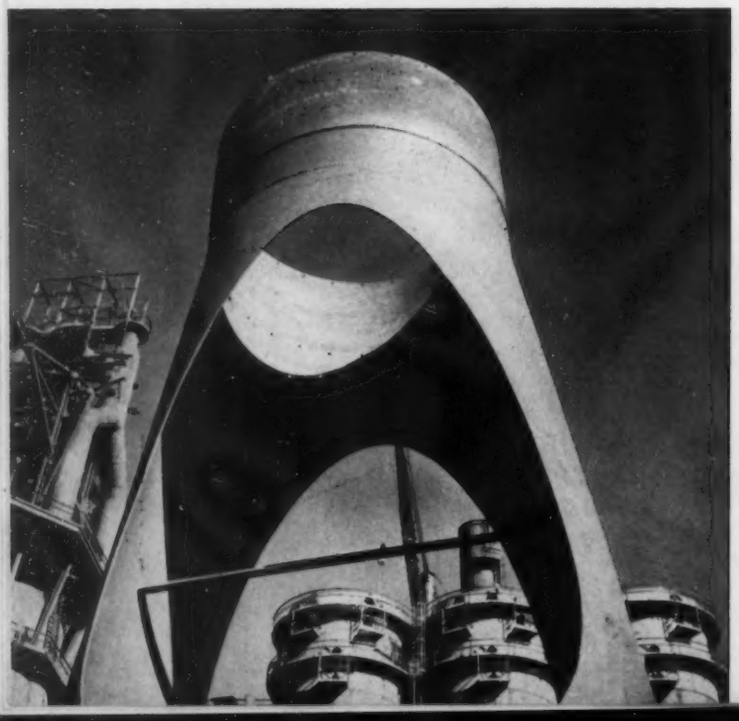
V. E. Schlossberg: We are interested particularly in the discussion on the length of time you leave a turbine on the line before taking it apart for inspection. The speaker refers to the Ford Company as having his turbines on the line since 1931. We have one on since 1938 which is a late start but maybe we will catch up with him yet. However, there is one point which I would like to have the speaker clear up and that is what about the gears and thrust bearings, would you let them go for the same length of time that you let the turbine go before inspection? Do you refer equally to reaction machines as well as to impulse machines or would you leave impulse machines on longer?

A. R. Smith: I think that on bearings and governor gears and such things, you can look at them any time, however, I am speaking about taking the whole top half of the turbine off and taking the rotor apart. I do not want to tell you how much less time you can run a reaction turbine than the impulse.

L. A. Terry: Mr. Smith has mentioned oil and coal as a source of fuel for gas turbines. I would like to ask what are the possibilities of using by-product gas from either blast furnaces or coke ovens?

A. R. Smith: I presume you people know how much dirt you get in gas engines from coke ovens and blast furnaces. My recollection of the steel mill blast furnace is that you have traps on every pipe leading from the blast furnace and the dirt flows down in these chambers by tons. We are only talking about the occasional piece going over that will completely ruin the gas turbine bucket and impair the efficiency. You have to separate that dirt out and that is our problem right now.

$500,000,000 U. S. STEEL EXPANSION PROGRAM



Needle eye view of new blast furnace construction in the South Chicago works of United States Steel's Carnegie-Illinois Steel Corporation, which is part of the corporation's $500 million expansion program. The needle's eye is in a huge section of gas main pipe which will become part of one of two new blast furnaces that will be among the largest in the world. Each will be able to make 500 thousand tons of iron a year. United States Steel is spending $50 million for modernizing and enlarging its facilities in the Chicago district as part of the national expansion program of the corporation. This brings to $300 million the total spent for these purposes in the Chicago zone since 1941.

Soluble Oils

FOR CUTTING AND GRINDING OPERATIONS

. . . . soluble oil mixtures are low-cost fluids and play an important part in cutting and grinding operations . . . .

By C. M. LARSON
Chief Consulting Engineer
Sinclair Refining Company
New York, New York

▲ BECAUSE of the shortage of fats in World War I the market for soluble oils was broadened. During World War II, when the cutting and grinding of metals played such an important part in this mechanized war effort, it was necessary to expand our knowledge of cutting fluids in order to keep pace with requirements for production and surface finish. Soluble oils played an important part in this achievement and soluble oils with extreme pressure additives, although still in their infancy, were coming into useage just as hostilities ended.

It is generally agreed that plain water was the first medium used to offset the generation of frictional heat in metal cutting. In 1883, F. W. Taylor, a pioneer of cutting oil research, demonstrated that when a heavy stream of water was directed upon the cutting tool at the point where the chip is torn from the turning steel, the cutting speed could be increased 30 to 40 per cent. The cooling effect of the tool and work with water were important, but rusting of the work and machine were more pronounced. To prevent this rusting, soda was added. Water with or without soda does not give a smooth surface. Due to its low viscosity or light body and poor wetting ability, it will not form a satisfactory lubricating film for the sliding of the chip over the face or lip of the tool. In order to improve the water soda mixtures, lard or mineral lard oils were added to give better lubricating value to the water compounds.

In order to get better emulsifying properties miscible with water than had been possible with the water soda and lard oil mixtures, soap cutting oil pastes were developed and this was the first notable step forward since thirty years before when Taylor first started experiments with water in the cutting fluid field. The cutting paste lacked ease of mixing and did not stay on in storage. It also lacked anti-rust properties; therefore, the way was open for further development of soluble oils of the soap and the sulfonated fat type. Later the petroleum sulfonates or mahogany soap type appeared.

Presented before AISE Annual Convention, Cleveland, Ohio, October 4, 1946

CLASSIFICATION

Today there are three types of material used to make soluble emulsions. They are as follows:

1. One class of "soluble oils" is made from mineral oil compounded with a neutralized sulfonated oil; either from fixed or petroleum oils.
2. The second type of soluble oil is made from mineral oil compounded with an alcoholic solution of soap.
3. The third variant is marketed as a paste made from a thick soap solution with or without mineral oil.

Of the three forms of soluble emulsifiers the last is least desirable. The second is made without expensive apparatus and requires less technical skill to fabricate. The first class, especially when petroleum sulfonates are used, as well as the second type, are easy to manufacture and are a safeguard against rusting of iron and steel parts. The petroleum sulfonates add detergency to the soluble oil mixture and give greater cleansing action of the machine parts and for long drilling operations.

The composition of the three types of soluble materials is listed in Table I.

Soluble oil shall be a clear, homogeneous stable oil; free from disagreeable odor, sediment and ingredients injurious to persons using it either in the original state or in emulsions. The soluble oil shall contain no materials which will cause corrosion of steel, copper or copper alloys.

The stability of the soluble oil shall show no appre-

TABLE I

Composition	Soluble oils		Soluble paste	
	Sulfonated type	Alcoholic soap type	Grade 1	Grade 2
Free fatty material	2 Per cent max.	6-20 Per cent max.	None	40 Per cent min.
Water content	5 Per cent max.	7.5 Per cent max.	30-40 Per cent	35-50 Per cent
Mineral oil content	85 Per cent min.	70 Per cent	40-50 Per cent	None
Soap content	.....	.....	15 Per cent min.	15 Per cent min.
Ash	2 Per cent max.	3.5 Per cent max.	5 Per cent max.	5 Per cent max.

ciable evidence of separation when subjected to cold weather conditions.

The soluble oil shall emulsify with water readily and shall form stable emulsions when thoroughly mixed in the proportions of one part of soluble oil with fifteen parts of distilled water. After 24 hours of standing at room temperatures in a four-ounce sample bottle, it shall show no appreciable oil or cream separation. For special hard water areas a hard water emulsion test is also recorded.

Emulsions of soluble oil shall not have a tendency to foam excessively. The residue from emulsions of soluble oil shall be soft in nature and free from hard, gummy residue. Soluble oils shall not be rancid, either in their original state or in emulsion.

Analysis and laboratory test methods are not of themselves a reliable guide to performance of soluble oils in service. Performance tests of soluble cutting oils are not available. Therefore specifications are either related to nomenclature or composition.

MIXING SOLUBLE OILS

Soluble oils should always be added to the water, water should never be added to the oil. The "raw" oil should be added to a sufficient quantity of water; at least one part of oil to four parts of water. Unless the oil is added to water, and sufficient water, the emulsion may invert and become droplets of water surrounded by oil instead of droplets of oil surrounded by water.

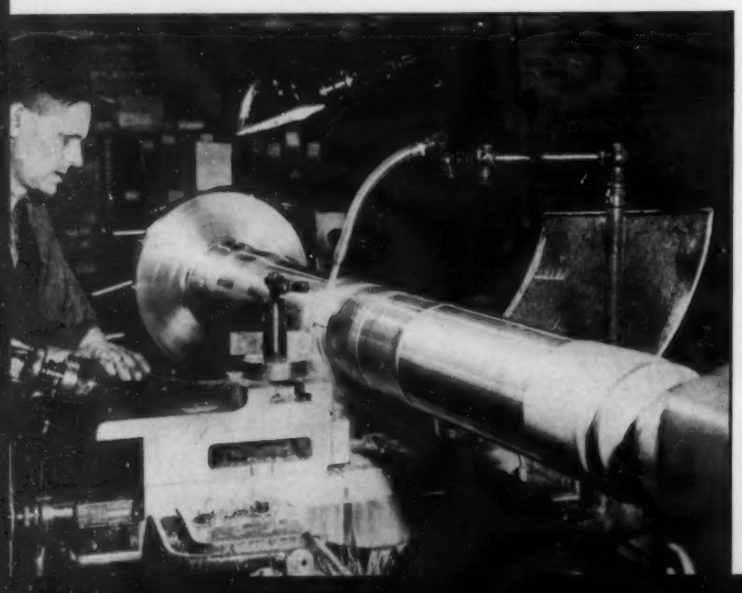


Figure 1 — Soluble oils are the best coolants for cemented carbide tools.

An inverted mixture can easily be detected by its slimy or pasty appearance and should be discarded. Some soluble oils contain water softeners as additives and may be mixed directly with almost any water commonly used in industry, whereas others require the hard water to be softened by treatment or by addition of softeners to the hard water before mixing in the soluble oil.

MIXTURES

The soluble oils are mixed with water to form emulsions in the ratio of one part oil to 10 to 100 parts of water for use as cutting or grinding fluids. They are fairly low in cost. They function primarily as coolants and the wetting and lubricating ability decreases as the water dilution increases.

Properly cooling the work prevents distortion of work and tool and permits closer tolerances. They also help wash away chips and keep the material clean. These soluble oil emulsions made with petroleum sulfonates prevent rusting of the finished parts and the machine.

The individual mixtures for specific jobs vary widely according to the job, rust-prevention, character of the metals being machined and the lubrication requirements of the machine. The finishes obtained are generally as good as with cutting oils. The richer mixtures of 10 and 20 per cent are used for broaching and pipe threading easier cutting iron and steel material. The 4 and 5 per cent emulsions are generally satisfactory for milling and boring, multiple spindle automatic screw machines and turret lathes; drilling, forming, turning, reaming, cutting off, tapping and threading all ferrous metals where cemented carbide tools are used. The leaner mixtures are also suitable for high speed light feed automatic machines for iron and steel, both easier or harder cutting metals when stellite or cemented carbide tools are used. Sawing and plain grinding of these ferrous metals use emulsions of 4 per cent soluble oil.

GRINDING

Lean mixtures are used for grinding since excessive oil in richer mixtures will clog the pores of grinding wheels and cause them to skid instead of grind. The grit size of the wheel must be taken into consideration as the wheel with a coarse grit makes a heavier cut, and, therefore, requires a richer mixture than a fine grit wheel in order to give the desired finish. The grinding of harder metals requires less lubrication and more heat dissipation as there is a less tendency for the metal

to wipe or draw. Therefore a much higher ratio of water to oil should be employed. In order to maintain the desired finish, the grinding wheel must be prevented, by the emulsion, from picking up dirt and grindings. A wheel that is loaded with dirt and grindings becomes glazed and will not cut cleanly. The emulsion must be given aid in maintaining a clean wheel by first, directing the flow in sufficient force to move the minute chips away from the wheel, and second, by furnishing a reservoir large enough and with sufficient baffles to enable it to settle out the minute chips. Because soluble oils are known to have surface-tension it is a further aid in settling out minute chips to impart to the emulsion a wetting ability or a breaking of the surface-tension. The wetting ability also aids in dissipating heat from the work piece.

A soluble oil that will perform suitable grinding operations must then pass the supreme test of stability of emulsion. This is where most oils fail because there is such a wide range in hardness of water in use. In the Mid-West, water of 12 to 56 and more grains hardness is encountered. Therefore, the soluble oil should either have a softening agent in it or have an excess of the emulsifying agent, so that a stable emulsion can be maintained with the harder waters. Otherwise it is necessary to recommend the addition of one-half pound to one pound of soda ash to 50 gallons of water before the addition of the soluble oil. Some use tri-sodium phosphate.

Where foaming occurs it is impossible to keep the grinding wheel clean because the fine particles are held in suspension. Soluble oil emulsions prevent the formation of flying metallic dust during grinding operations.

Figure 2 — The four and five per cent solutions are usually used in boring operations as on this diesel crankshaft.

CEMENTED CARBIDE TOOLS

With the advent of cemented carbide tools permitting higher cutting speeds, soluble oils are looked upon with new favor because they are the best coolant, and such tools develop tremendous heat. In some cases soluble oils have been unsatisfactory on carbide tools and upon investigation the method of delivering the coolant to the work resulted in the tool being shielded by the chip that is being removed. As a result, intense heat is generated in the tool and suddenly at the end of the stroke the tool does receive a bath of relatively cool emulsion. Cracks then occur and the tool edge begins to disintegrate.

The correct solution is to direct the stream of coolant so that it will enter beneath the chip and keep the tool constantly and evenly cooled. When so applied no cracking results. One other feature of this problem is the avoidance of high pressure streams of coolant. Many delivery nozzles are "necked" down which builds up velocity, resulting in the coolant hitting the work at high velocity and splashing. When this condition exists, the coolant is not staying in contact with the work long enough to permit effective heat transfer. The answer is to eliminate all restrictions, deliver a large volume of coolant at low pressure so it forms a ball around the tool and thus has the opportunity to absorb heat effectively.

EXTREME PRESSURE SOLUBLE OILS

Not to be outdone, soluble cutting oils have gone to chemical additives to increase their scope and machining efficiency. In steels, in the general classifications of 1020, where drilling, reaming, and turning are developing too much built-up heat in the work piece, an ordinary soluble oil will remove the heat but will not prevent some chip welding, nor will it give the desired finish. This is particularly true in the outside diameter turning of a small fillet where the cutting edge radius is so small that the built-up heat in the cutting tool cannot be dissipated through the tool. Under these conditions there is a definite need for extreme pressure soluble oils, because under actual tests a mixture of sulphurized soluble oil mixed with water in a ratio of 1 to 8 has prevented chip welding under heavy duty service.

Chlorine is also introduced to produce a better finish at higher cutting speeds. Sulphur is needed with chlorine emulsions when high depth of cuts are involved in order to provide the required anti-weld. Phosphorus additives also help improve the surface finish when ferrous metals are machined. It is thought that this additive reduces the chip temperature. It is advisable to use a stable chlorine additive as decomposition under high heat conditions might form hydrochloric acid. The sulphur and chlorine can be added to the soluble

Figure 3 — The leaner mixtures are usually used on the lighter feed automatic machines.

oil in much the same way as sulphur chlorine petroleum cutting oils, or may be added as sulphurized fat with chlorine added in addition or as sulphur chlorine fatty oil mixture with soluble oil.

Odor is sometimes a factor with these extreme pressure oils and should be eliminated or masked. Graphite, either colloidal or amorphous has been used in the proportion of 0.05 per cent graphite in the soluble oil. Under certain test conditions the graphite treated emulsions gave better results than the untreated soluble oil-water solutions. In some instances it is hard to maintain stable emulsions with these extreme pressure soluble oil mixtures.

Various extreme pressure machines are used to determine the film strength, wear curves or torque of these sulphurized or sulphur-chlorinated soluble cutting oils. Our four-ball tests give wear curves and the seizure and weld points. Ten per cent emulsions of various additive soluble oils are used. The SAE machine also gives the weld point load comparisons. The Almen machine is better adapted to give torque characteristics or lubricity and lubrication factors under high load conditions. Here the chlorinated soluble oils show better results. So far it is impossible to correlate these various extreme pressure machines with cutting or machining performance.

ANTI-FOAM CONCENTRATES

About 10 per cent anti-foam addition agents are added to soluble oils to break the foam. This keeps the soluble oil emulsion from frothing out of the machine reservoir. Foaming causes trouble in pumping and an oil which is full of air bubbles cannot perform its cooling and anti-welding function. In grinding operations, foaming carries over metal particles, and also loads the wheels, causing burning and checking on the parts. Anti-foams do a good job in checking the froth caused by aeration of the emulsion and in giving longer tool life and better surface finishes.

MACHINE LUBRICATION

In the past several years emulsions have been used in certain machines where the design caused the coolant to enter the lubricating oil system, causing sludging of the lubricating oil and resulting in bearing failures. Either the machine should be corrected mechanically to prevent the coolant entering the lubricating system or an emulsion should not be used. Neither should the bearing lubricating oil leak into the soluble oil emulsion.

CLEANLINESS

Soluble oil emulsions have no odor and women operators like them as they soften their hands. The pieces are cooler and easier to handle. Clothes do not become stained. Germicides are added to soluble oils, generally in the ratio of one part germicide to every 600 parts of the soluble cutting oil emulsion in the machines. This is renewed every two weeks.

CONCLUSION

Although soluble oil mixtures are low-cost fluids and play an important part in cutting and grinding operations, nevertheless, they are not yet the universal cutting fluid. The extreme pressure soluble oils do show promise and will widen the scope and aid in broaching operations. Yet higher power loss and certain machine lubrication difficulties hold down their general useage.

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DISCUSSION

PRESENTED BY

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E. S. Carmichael: Mr. Larson's paper emphasizes certain fundamentals of soluble oils and their applications which are quite important to plant personnel. For example, the statements on "mixing soluble oils" cannot be overemphasized, because even today, with technical information available on this subject, some plants continue to use incorrect procedures in preparing soluble oil emulsions.

In our opinion, the finishes obtained with the use of soluble oil emulsions are not as satisfactory as those obtained when non-soluble cutting fluids are employed. Soluble oils are generally used for "hogging" or roughing cuts where removal of a large amount of metal in a relatively short time is practiced. For the light, finishing cuts, non-soluble oils are, in general, more effective.

Although considerable progress has been made in imparting greater oiliness and higher film strength

characteristics to soluble oil emulsions, the non-soluble cutting fluids are definitely superior in these respects. For example, while the extreme pressure soluble oils are quite suitable for most machining operations, they are not too satisfactory for use in heavy duty threading or internal broaching operations.

We concur with Mr. Larson in that graphited soluble oils show improved performance characteristics in some operations. However, under certain conditions encountered in the field, instability of the mixtures with respect to separation of graphite may be a factor.

Relative to the use of laboratory extreme pressure machines for predicting cutting efficiency, it has been our experience that the results of these tests are only indicative, and as such, must be interpreted with extreme care. No single laboratory test machine is available that can be utilized effectively in predicting performance properties of cutting fluids for various machining applications in the field.

C. T. Lewis: I have a few remarks or rather questions to make in regard to the paper.

The writer states, in regard to mixing, that some types of soluble oils are more stable than others. I was wondering what effect the particle size as the result of the type of mixing used had on the stability of the emulsion itself. Is it poured in and stirred up with a stick or is it put through the suction line of a pump and thereby given a high rate of shear? What would the resultant particle size effect be on stability and the effectiveness in actual use of the emulsion?

In regard to the grinding operation, the question in my mind would be, to what extent does the addition of anti-foam compounds affect the rate of chip settlement?

In regard to the extreme pressure soluble oils, it was mentioned that in quite a few cases they were not stable. I was wondering if he could give any relative stability comparison with the conventional type of soluble oil normally in use?

When adding an anti-foam concentrate, assuming that the anti-foam action takes place, and breaking up of the foam conditions occur due to the change in surface tension, would not this same reaction result in a higher wetting of the metallic surface and consequent increase of lubricity and the effective cooling of the work?

The writer also spoke of the used emulsion having to be emptied out every two weeks or every three weeks, as far as odor is concerned. What is the recommended procedure for sterilization of such material? Does proper sterilization prolong the useful life of the given soluble oil emulsion?

The last question in my mind is: What factors tend to promote deterioration of the soluble oil emulsions during the periods that the solution is dormant or not in use, regardless of whether it is twenty-four hours, a week, or more?

C. M. Larson: The question of mixing is one that has been given much attention probably to a greater extent than any other phase especially in the larger plants. The shop used to take a drum and stir the oil into it and paddle the soluble mixture by hand. The better equipped shops today have a central circulating system. The solution is sent from central mixing and storage up through the plant. I think you will find today in most of the better shops a great deal of attention is given to proper soluble oil mixing, using mechanical mixing means.

C. T. Lewis: What effect would the particle size have on stability?

C. M. Larson: You mean mechanical mix versus paddling?

C. T. Lewis: Not necessarily that, but, in other words, you might use a rotary type mixer or an air jet type mixer. Each one of them, I think, would have some effect on the resultant particle size and consequently on the effective stability of the emulsion.

C. M. Larson: Once oil in water emulsions are made at normal room temperatures, I doubt whether any different mechanical means of agitation would change that form. That is a form that is set by nature or emulsifying agent. I doubt if you can change that water emulsion form. However, I have never seen microphotographs of emulsions made by different forms of agitation. There may be others who have. I do not think we have progressed that far in cutting fluids as yet. There are a lot of factors of that kind that can be looked into, but when it comes to the mechanics of emulsion, that is a thing that is set by temperature and the time of agitation.

Now as to the rate of chip settling, I am not in position to give you those figures. Unquestionably with the absence of foam more complete settling of chips take place. As to the stability of the extreme pressure soluble oils, they will show on arrival the same oil in water emulsions that you get on the other type of soluble oils, but when stored over periods of about three months there is a tendency to oxidize or take some form where they do not readily go into perfect emulsions. That is a matter of storate time and has nothing to do with the product as originally manufactured.

Now on this question of changing the oil every two weeks, I did not intend to give that impression in the paper. They generally examine the solution and as a matter of precaution, every two weeks add a little more of the germicide to keep it sanitary.

The last question was what causes soluble oils to deteriorate, especially in storage periods. That, of course, depends upon the type of soluble oil, the hardness of the water and its treatment and other factors including cleanliness, metals and contamination.

R. A. Kraus: Have tool life performance tests been run using standard conditions in so far as possible, but varying the nature of the emulsifying agent between the alcoholic stabilized type and the petroleum sulphonate type, and if so has any difference been noted? I realize other factors may completely overshadow any difference noted since many other variables are far more important.

C. M. Larson: No, there have not. The Independent Cutting Fluid Research Committee has attempted a cutting fluid test and machinability setup in order to check cutting fluids. Until such comparisons are made this question as to which type of soluble oil is better, cannot be answered.

Surface Preparation

OF SEMI-FINISHED TOOL STEEL

. . . . reviewing chipping, grinding, and some of the metallurgical methods employed in maintaining surface quality of semi-finished tool steel for rolling and forging . . . .

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▲ TOOL steels are generally used for cutting, shearing, and forming tools, but many uses besides tools require steel made in accordance with tool steel practice, and we find tool steel manufacturers also making aircraft, ordnance, hobbing, magnet, ply, bearing, low expansion, nitriding, and corrosion and heat resistant steels. To meet the quality demanded in these applications extensive inspection and testing is required, which begins with the raw materials and continues till the steel is ready to ship. The open hearth process is used to produce tool steels of certain kinds, but many types of tool and special steels can be made only by the crucible or electric furnace process. The ultimate value of a tool depends as much on the skill with which it is melted and worked into its finished shape, as on the expertness with which it is heat treated.

Tool steel of quality must be free of injurious surface defects, and to meet this requirement without excessive scrap loss in the finished product, careful and thorough inspection and preparation of the semi-finished surface is required. Surface imperfections in the original ingot as well as defects arising in hot working, must be removed to prevent their appearing in the finished steel. The surface preparation of semi-finished steel for rolling and forging is carried out by a number of operations. These involve the metallurgical measures that may be used to minimize conditioning as well as the methods of inspection and surface conditioning.

The removal of surface defects from semi-finished tool steel is usually accomplished by either chipping or grinding. The method of conditioning adopted is governed by the quality of surface required, and the composition of the steel. It is necessary for a number of applications to clean the surface free from scale so that the defects may be more easily detected. For the chipping operation, the scale may be removed by breaking it off with a wide edge chisel inserted in a pneumatic hammer, or more generally by pickling. In grinding, the scale is completely removed in the beginning of the operation, leaving a clean surface on which it is possible to readily detect practically all the surface defects. The surface to be conditioned is inspected, and the injurious defects to be removed are located and marked.

CHIPPING

Chipping is effective but time consuming and laborious, hence scarcely applicable for the removal of large numbers of very fine seams or where complete freedom of surface defects is required. At present more economical methods have been developed for mild steels, so that chipping is mostly used in conditioning of carbon

Figure 1 — Chipping with the pneumatic hammer is done primarily on the softer steels.

Presented before AISE Philadelphia District Section Meeting, December 7, 1946

and low alloy tool steel billets of sizes for jobbing type of sheet and merchant mill rolling.

The chipping operation is commonly carried out with a chisel inserted in the bushing of a pneumatic hammer, which is held inclined to and pressed against the surface of the steel to be chipped as shown in Figure 1. In this manner, both the depth and direction of cut can be controlled in removing surface defects. The wide edge chisel shown on the right of the operator is the type used for cleaning off scale from the billet surface prior to the chipping operation.

The air hammer shown is capable of delivering up to 2500 blows per minute, weighs 13½ pounds, and is 13⅝ inches in overall length. This type of hammer is well adapted to the chipping of high carbon billets. The cycle of the piston which has a 2½ inch stroke is controlled by a diaphragm type valve. The life of the hammer is up to about 2800 chipping hours, when it is either scrapped or rebuilt depending on its condition. The parts that receive the greatest wear are the piston, barrel, trigger and bushing, listed in sequence of increasing wear. Routine lubrication is done by either applying the lubricant through the throttle or by use of a built-in lubricator type handle.

Since the development of the air hammer, chipping tests on pneumatic chisels have been performed to determine which chisel composition is superior, effects of changing air pressure, and effect of hardness of the steel chipped. Unlike testing fixed tools where the angles with the work are constant, the accuracy of the data in pneumatic chisel testing is governed largely by the skill of the operator. To illustrate the effect of these factors, pneumatic chisels of the following compositions, heat treatments and hardnesses were tested as shown in Table I.

Flat edge ¾ in. octagon pneumatic chisels were used throughout the tests. The shank ends of the chisels were forged and heat treated to a range of 45 to 50 Rockwell C. This hardness range has been satisfactory for shanks, it being rare for a shank within this range to break. The cutting edge was forged to ⅞ in. wide and ground to 60 degrees, and the corners were filleted to a 1/16 in. radius. The cutting edges were heat treated to the hardnesses given to obtain the highest cutting qualities.

The chipping tests were performed along the edge of plates ½ in. thick by 40 in. long and 20 in. wide. These plates analyzed C-0.43, Mn-0.75, P-0.022, S-0.022, Si-0.22 per cent, and were heat treated to 174 Brinell and 302 Brinell. The plates were secured rigidly, and a 20-lb weight on the end of a wire rope fitted over pulleys attached to a hammer, assisted the chipper in making continuous and uniform cuts.

Table II shows comparative wearing rates on the given chisel compositions, used on test plates of different hardnesses and with varying air pressures used on the hammers. The chisel wearing rate is computed by dividing the weight of chips cut by the weight lost from the chisel.

The carbon steel chisels reach their peak wearing rate and failure much earlier than the other compositions. The tungsten and chrome chisels are superior at the higher air pressure and steel hardness. The chrome chisels have the best wearing qualities, but they are difficult to heat treat in practice without cracking. The

Figure 2 — Billet grinding is usually done with the aid of suspended swing frame grinding machines.

tungsten composition gives the best service and production in chipping of tool steel billets.

The endurance of chisels is decreased by increasing the air pressure, but much heavier cuts can be made in a shorter time. Increasing the air pressure from 80 to 112 lb, reduces the chipping time by 30 per cent, and

Figure 3 — This 25 hp machine uses a 24 in. x 3 in. wheel.

TABLE I

Type	Heat treatment	Rockwell C edge hardness	C	Mn	Si	Cr	W	V	Mo
Carbon	1450 F — Water 400 F — 2 hr	60	0.81	0.33	0.29	....	....	....	...
Tungsten	1675 F — Oil 380 F — 2 hr	59	0.49	0.32	0.15	1.09	2.12	0.22	....
Silico-manganese-molybdenum	1600 F — Water 450 F — 2 hr	61	0.57	0.77	1.49	....	....	0.16	0.58
Chrome	1675 F — Oil 390 F — 2 hr	59	0.46	0.76	0.64	....	....	....	0.63

TABLE II

Chisel Wearing Rates (Weight Chips ÷ Chisel Wear)

Type	80 psi air pressure Plate hardness 174 Brinell	80 psi air pressure Plate hardness 302 Brinell	112 psi air pressure Plate hardness 174 Brinell
Carbon	1,620	110	1,490
Tungsten	7,490	700	3,580
Silico-manganese-molybdenum	8,860	450	2,760
Chrome	19,160	850	4,610

the weight of the chips is increased by 50 per cent, while the chisels wear 100 per cent faster than at the lower pressure.

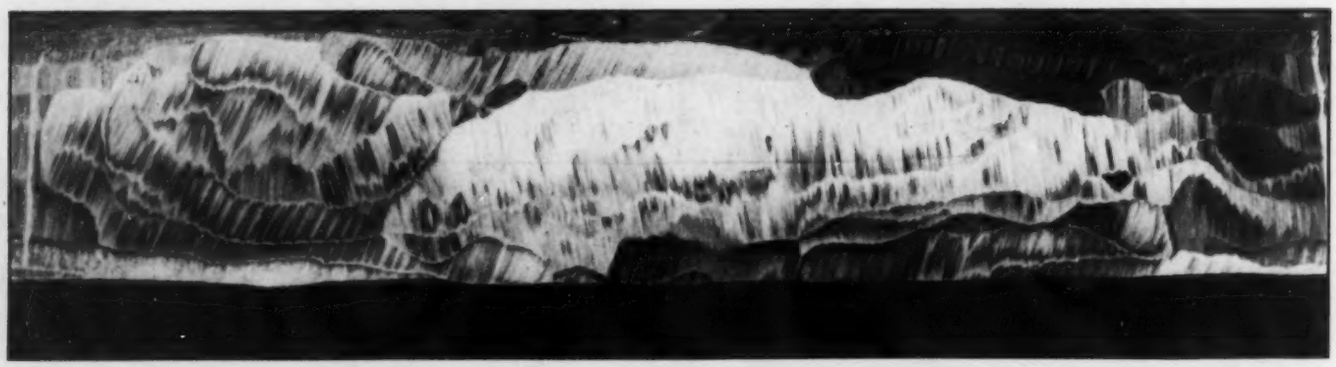
The life of the chisels and production is materially decreased by increase in hardness of the steel to be conditioned. High production is obtained on soft steels that chip easily with long, fairly thick chips as compared to tool steels that run up to 300 Brinell. On chipping tool steels the chips are thin and short and break and fly off the surface readily, so that it is frequently necessary to re-introduce the chisel into the work. Over twenty times more weight of chips can be cut from steel at 174 Brinell than at 302 Brinell hardness in the same time and at the same air pressure.

Production chipping values depend on many factors that vary from plant to plant. Some of these are the type of steels, surface condition, billet sizes, methods of processing, types of inspection and requirements in the finished product which have an effect upon chipping cost. When exceptionally good surface is required, steel is generally pickled prior to conditioning, so that the defects are more readily detected. Under these conditions more chipping is done in removing surface defects, so that approximately 50 per cent less steel is chipped with about five times greater chipping loss than on grades that are not pickled. When steels that scale easily are re-heated enough times in processing with sufficient reduction in hot-working, as in some types of sheet rolling, they generally do not require chipping because practically all of the injurious defects are scaled off.

GRINDING

Grinding is more costly than chipping, but a more effective method of surface conditioning steels such as stainless and the air-hardening types, or where the service intended for the finished product is such, that only a complete removal of all surface defects and decarburization offers sufficient insurance before proceeding with finishing operations. Grinding is generally done across the billet, and hence across the seams, which are practically always longitudinal. This grinding across the seams causes them to appear more prominently and therefore more easily detected on inspection, than is the case with chipping which is generally done along the seams. When transverse cracks occur on billets and on ingots where this condition happens more frequently, then it may also be necessary in both cases to grind

Figure 4 — This billet of tungsten hot work die steel developed a horizontal grinding crack.



along the longitudinal axis to completely remove the defect.

Suspended swing frame grinding machines as shown in Figure 2 are generally used for billet grinding. The machines are usually hung by a chain block from an overhead mono-rail trolley, and consist of a horizontal frame with a motor mounted at the rear which drives the grinding wheel spindle at the front end through belts. The operator can move the machine in any direction since it is suspended at about its center of gravity and is not rigid. A weight hung next to the handlebars prevents excessive fatigue in applying pressure to the work during the operation. The rate of cut which increases with pressure, and the continuous relative movement between wheel and work removes stock economically. Increase in pressure increases wheel wear, and the amount of pressure that can be applied is also determined by the grade and condition of the steel to be ground, the safe limits of the wheel and fatigue of the operator.

The machines shown are 10 hp units, approximately 9 feet long and are adjustable for two speeds. The machines mount wheels 18 in. in diameter by 2 in. wide and with an 8 in. arbor hole. Economy in production and wheel wear is best achieved when the wheel is operated up to its correct speed. If the speed of the wheel is decreased, the wheel will act softer and wear away more rapidly. When the wheel is worn considerably smaller than the original diameter, then the belts are shifted to the large diameter pulleys on the machine. This increases the rpm of the spindle and brings the surface speed of the wheel back to the original rate, thereby offsetting the soft action of the wheel. On the 18 in. wheel size, the belts are changed to the larger pulleys when the wheel is worn to 14 in. in diameter and the wheel is finally discarded when it is reduced to 10½ in.

Work chatter during the grinding operation, machines that are not properly balanced and have loose or worn working parts, not alone shorten wheel life but may cause injury to the work. The grinding bed on which the work rests should have a firm foundation and the work should be properly wedged in with cleats or clamped to maintain the required rigidity during grinding.

The grinding dust collecting system shown in Figure 2, combines the exhauster and dust collector in a single compact unit. This type of collector removes the dust by means of centrifugal force and gravity. A rotating turbine-like impeller draws the dust laden air into a circular chamber and separates the dust and discharges the cleaned air. The cleaned air, which forms the primary circuit located in front of the impeller, passes into a scroll from which it is exhausted through a discharge pipe to the atmosphere above the roof line of the building. The dust separated by centrifugal action converges at the outer edge of the impeller and passes through a narrow annular opening into a dust chamber located in back of the impeller forming the secondary air circuit. The dust delivered into the secondary air circuit passes as a continuous stream through a port in the base of the housing to a closed hopper below. The interior of the housing that receives the impact of the dust particles is fitted with chilled cast iron liners to reduce wear.

Grindings rich in expensive alloys can be separated from the low alloy grindings by a dust control system, by properly scheduling the grades of steel to be ground and segregating the dust. Since grindings consist of approximately one-fifth to one-quarter wheel grit, it is difficult to use any appreciable amount as scrap in single slag basic electric melting, because it may interfere with the proper shaping of the slag. Steel grindings may be separated from the wheel grit magnetically or the metallic content can be recovered by a smelter.

Figure 5 — In some cases, dry grinding will not remove the cracks.

Figure 3 shows the method of mounting a 24 in. diameter by 3 in. wide wheel with a 12 in. arbor hole, on a 25 hp machine generally used in grinding large billets and ingots. The machine has three speeds. To maintain uniform wheel surface speed, the belts are shifted to the larger pulleys when the wheel is worn to 21 in. and again when the wheel is at 18 in. in diameter, and finally the wheel is discarded when it is reduced to 15 in. When mounting wheels it is necessary that the flanges bear uniformally against the sides of the wheel. Blotters are used between the wheel and flanges to reduce the wear on the flanges and to take up the slight roughness in surface of the wheel and to distribute the pressure evenly.

The majority of billet and ingot grinding is done with resinold or rubber bonded wheels, due to their strength and because they can be operated at the high speed of 9500 surface fpm permitted by the safety code. There is less danger of cracking steel with a vitrified wheel which operates at a maximum of 6500 surface fpm, but since rate of production increases with wheel speed, it is

Figure 6 — Defects due to blowholes must also be removed.

more practical to render the steel less sensitive for the grinding operation. The abrasive for grinding semi-finished steel is fused aluminum oxide, which is bonded with synthetic resin to give the wheel the required hardness and strength. The characteristics of a grinding wheel are dependent on the kind and size of abrasive used, process by which the wheel is bonded, and the grade of hardness. Each grinding department sets up standards to fit its own needs as established by study and trial. Due to differences in operation it is seldom found that two plants will specify wheels of identical characteristics, even though the steel being ground is the same. The testing of wheels does not involve any special technique or equipment. The superiority of one wheel over others is generally established by placing a number of each under actual operating conditions, and for a long enough time so that an adequate study of all the factors can be made.

Wheel performance is judged by the rate of material removal which varies greatly between mills due to the kind of steels conditioned, type of wheel, methods employed, and the type and condition of equipment. In general, the harder the grade of steel, the lower the rate of material cut and the higher the wheel wear. A grinding wheel will remove approximately 20 to 30 per cent more material with a 30 to 50 per cent longer wheel life, when grinding soft steels as compared to its performance on the harder grades.

Grinding loss which mainly depends on the condition of the surface and the area per unit weight of billet to be ground, will vary from as low as 1 per cent for good surface conditions up to 10 per cent for poor surfaces, the average normally running 4 to 5 per cent. When the grinding loss runs over 10 per cent, the condition of the steel is generally questionable, because there is always the danger of defects appearing in the finished product from such poor quality, and the billets may be ground so much out of size and shape as to make them troublesome in handling during rolling.

Steel that is being ground is continually expanding and contracting, a condition which causes high stresses to be developed momentarily on the surface of the steel. The degree of stress that will be developed on the surface of the steel will depend on the skill of the operator, condition of equipment, speed and hardness of the wheel, area of contact between wheel and work, and the severity and length of time of grinding on any one spot. The amount of stress that the steel can tolerate without cracking will depend on its condition and composition. The operators are generally paid on an incentive basis, and therefore prefer fast cutting wheels which are hard and durable. Both the harder grade wheels and tendency to higher production may lead to cracking of steel, especially on the sensitive grades.

If the stresses are not too high and the steel is tough enough, no permanent injury is done during the grinding operation. Grinding cracks are generally limited to the hard steels that may contain an appreciable amount of retained austenite, and that are not able to withstand rapid heating and cooling cycles. This condition is illustrated in Figure 4 on an unannealed 4 in. sq billet of tungsten hot work die steel which shows a crack that developed during grinding. If the severity of grinding is too great and it is localized, causing the surface of the steel to rise above its critical temperature, cracks may occur on sensitive grades due to air hardening as illustrated in Figure 5 which shows a crack (magnafluxed) in an annealed 12 in. square ingot of high speed steel caused by these adverse conditions. Cracks of this type and especially on unannealed air hardening steels can rarely be removed by dry grinding, because the cracks keep propagating themselves deeper while they are being ground away.

The danger of producing grinding cracks may be minimized without decreasing production in grinding on sensitive grades, by slow cooling the steel immediately after hot working, grinding warm, annealing before grinding, or by grinding warm after annealing. The steel is rendered more plastic by either of these processes and especially by the last method mentioned, so that it has a larger capacity for local yielding, and hence can accommodate itself to grinding stresses with less danger of cracking. On grades that are rich in carbon and alloying elements such as 2 per cent C-9 per cent W tack die steel, it may be advisable to wet grind with a finer grit wheel after annealing. Wet grinding not alone avoids the danger of grinding cracks, but it is also advantageous for detecting the minutest defects in the subsequent inspection, as very fine grinding is possible.

The air hardening steels are generally stress relieved or stored in a warm place, protected against the weather

immediately after grinding to prevent cracking due to any residual stresses resulting from the grinding operation.

SURFACE QUALITY CONTROL

The surface quality of the finished product is governed mainly by the condition of the semi-finished steel from which it is forged or rolled. It has long been recognized that a close relationship exists between surface quality produced in melting and hot working operations and occurrence of surface imperfections on the finished steel. Variation in factors that affect surface quality within one plant may not show the same relationship to quality in another plant. The many complex variables involved, permit only a brief outline in this paper of some of the methods employed in melting and hot working to improve the surface of semi-finished tool steel.

The most prevalent defects such as seams, cracks and scabs generally originate in the ingot, so that the method of melting, pouring and handling of the ingot after stripping is an important procedure in improving the quality of semi-finished surface. The first step necessary in the melting of tool steel is careful selection and testing of raw materials.

Steel scrap is segregated and classified according to its size and chemical composition to facilitate consistent quality in melting. Contamination that interferes with the proper shaping of the slag, and impurities such as copper, tin, arsenic and antimony that have an adverse effect on hot-workability causing poor surface condition, and that cannot be eliminated during melting, must be held to a low enough content in the charge and additions to render them harmless. The most common of these elements are tin and copper which cause an intergranular weakness, resulting in a rough surface on the steel during hot-working. The ill effects of copper may be overcome by the presence of sufficient molybdenum or nickel in the steel. The effect of tin is more severe than copper, even more so, when both are present and especially in high carbon and alloy steels.

Sulphur, selenium, and lead intentionally added to improve the machinability of steel, columbium used to prevent inter-granular corrosion in stainless steel, and excessive amounts of boron above the requirement for hardenability also have a marked tendency to decrease hot-workability. Phosphorus in normal amounts has little or no effect on hot-workability and is used as a ferrite strengthener on such grades as surgical brace steel. The lowering of phosphorus from 0.055 to 0.015 per cent on Hadfield manganese steel by using a charge and additions low in P, makes a decided improvement in its hot-working properties and surface quality. The elements mentioned in this group can be reduced in content during melting in the basic practice.

Some tool steelmakers use muck bar or sponge iron as part of the charge because of the relatively greater freedom of the iron from detrimental alloys, nonmetallics and gases in this type of melting base. Whether alloys, inclusions or gases are detrimental depends on their amount and condition which can be tolerated in a

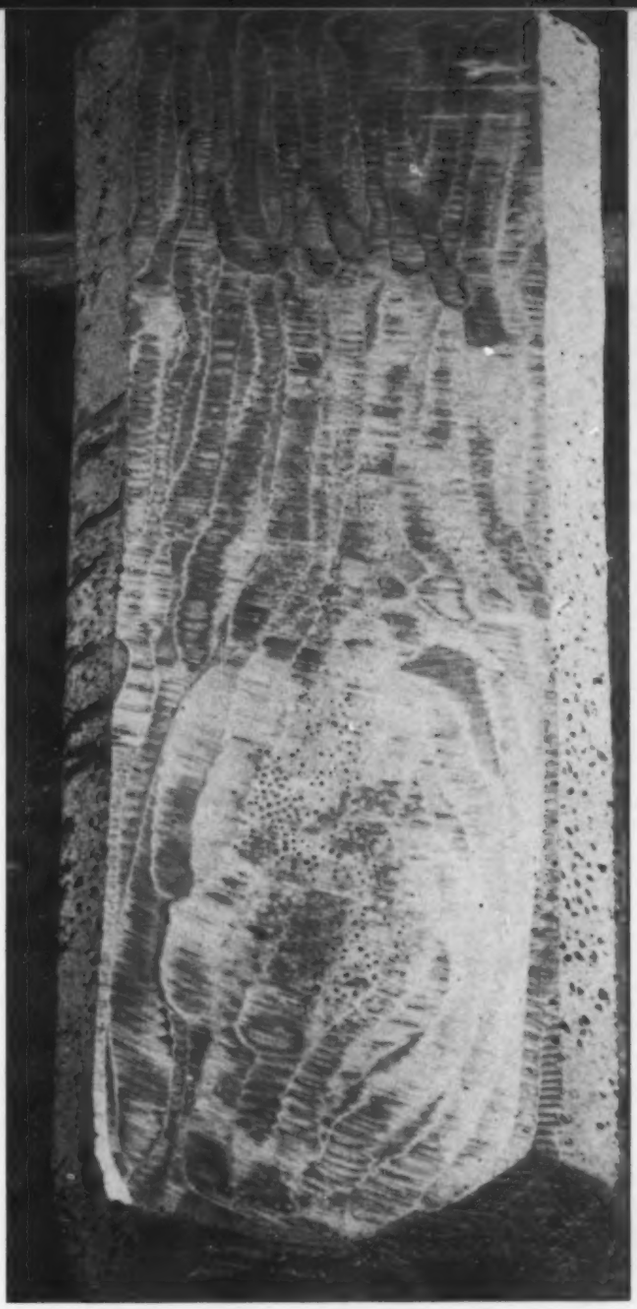


Figure 7 — Porosity may also require much reconditioning time.

grade of steel without increase in production cost and without vitiating the service performance of the finished product. Since tool steel must be well deoxidized, it does not possess the advantages of the effervescing action of rimmed steel as it enters the mold to prevent inclusions from being trapped in the surface layers of the ingot. If inclusions trapped in the metal during solidification are large or located in the grain boundaries, they may initiate the formation of internal and surface imperfections in the steel during hot working or heat treating. Non-metallic inclusions are composed principally of oxides, sulphides, carbides and nitrides. They may be caused by chemical reactions during steel making, erosion of refractories, entrapped slag, and precipitation during solidification. Some inclusions probably remain in the steel in a colloidal state. Carbides in the form of envelopes experienced on high carbon high

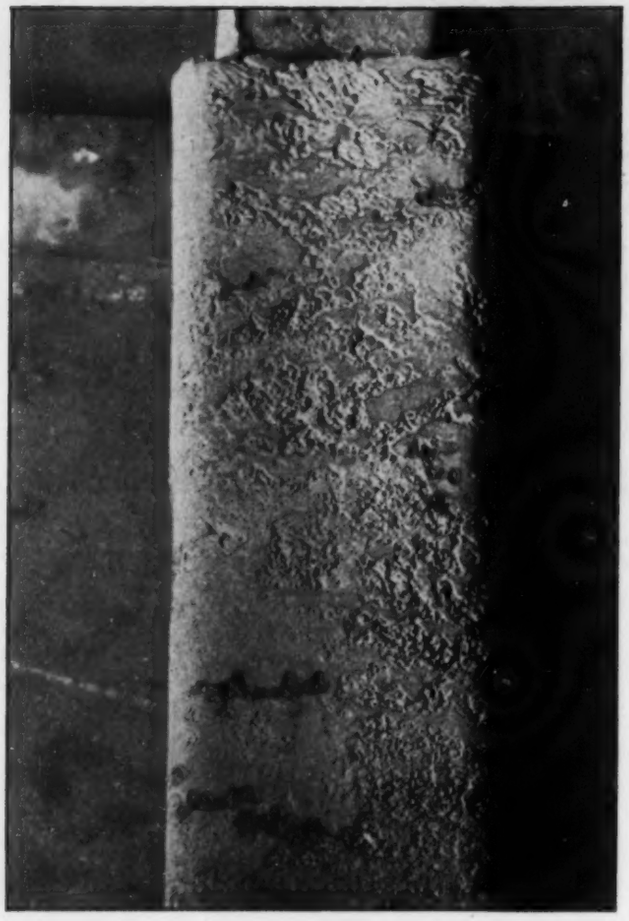


Figure 8 — Slow or cold pouring of ingots may produce rough surface ingots.

alloy steels, that cannot be destroyed on heating or hot working will act like non-metallic inclusions. During hot working, inclusions that are hard and refractory such as alumina retain their shape and particle size; those that are refractory and brittle such as the silicate glass type break up and the fragments are strung out, while the sulphides which are plastic are elongated with the steel. Excessive amounts of inclusions and when they are large enough in size to form discontinuities of harmful proportions must be avoided especially on the harder steels. On the other hand, inclusions that are submicroscopic in size and evenly distributed have the beneficial qualities of refining the grain size of some steels. Nitrogen, which may cause blowholes and non-metallic inclusions under certain conditions, is used in stainless steel for the purpose of stabilizing austenite and inhibiting grain growth.

Subsurface porosity or blowholes in the outer shell of the ingot which are oxidized during heating for rolling or forging, produce surface defects in the resultant billet. Figure 6 shows blowholes on the ground surface of a 9 × 12 in. ingot of 0.75 C low alloy steel containing a hanger crack near the top. Some blowholes are deep seated as shown in the lower left side which was ground to a depth of about a quarter of the ingot thickness. Figure 7 shows surface porosity on a ground 12 in. square ingot of high speed steel. These cavities are caused by many conditions some of which are: trapping of gases by steel during solidification of the ingot, splashes and foaming during pouring, damp molds, pouring too slowly, badly fire-cracked or cut molds, mold coating containing hydrogen, unclean crusty molds, and improperly dried bottom pour assembly. Molten steel is capable of absorbing large volumes of gases such as hydrogen, nitrogen and oxygen in the form of iron oxide. If these gases are trapped while seeking escape, due to increasing viscosity of the metal during solidification, then cavities are formed. These cavities may be formed by carbon monoxide, or by other sources which establish surfaces within the metal to which hydrogen and nitrogen can diffuse forming cavities and causing them to grow. During solidification, nitrogen present in excessive amounts and hydrogen may diffuse to the surfaces formed in the steel by the presence of inclusions, iron oxide and evolution of carbon monoxide resulting from the carbon plus iron oxide reaction.

Quality of steel in melting may be controlled under normal slag and furnace conditions by the following briefly outlined practice:

1. The raw material should be properly selected to form a well balanced charge. Impurities and moisture must be held to a minimum in the raw materials. Hydrogen may be introduced into the steel in various ways one of which is by moisture in the raw materials. The purity of the charge is of great importance in electric furnace melting because there is less bath activity throughout the course of the operation as compared to the open hearth process. Non-metallic matter tends to build up in a closed cycle in electric furnace shops which use their own scrap. Outside scrap or virgin material may be used as part of the charge to overcome this condition.
2. Maintain an active bath during the oxidizing period, the extent of which is governed by carbon and alloy content. The iron oxide fluxes the inclusions which coalesce readily and rise to the surface and enter the slag. Both hydrogen and nitrogen are eliminated to an extent by vigorous boiling of the bath in the early stages of melting, and by shortening the deoxidation period since during this time and especially in the presence of appreciable amounts of carbide in the slag and residual silicon in the metal, the absorption of hydrogen and nitrogen is favored. To control the bleeding of ingots of stainless steel some plants remove hydrogen by flushing the molten steel in either the furnace or ladle with an inert gas such as argon.
3. Follow a preliminary deoxidation practice prior to alloy additions to avoid oxidation of the additions.
4. Make the alloy additions long enough before tap for solution and elimination of any impurities caused by the additions. Artificial stirring of the bath promotes a more uniform solution of the alloy additions and also assists in washing out suspended non-metallics and gases.
5. Reduce sulphur, iron oxide and nitrogen as low as possible to form a minimum of sulphide, oxide and nitride inclusions during final deoxidation. Cavities due to nitrogen may be overcome by the addition of titanium during final deoxidation. Carbon monoxide evolution caused by incomplete deoxidation can be readily overcome under normal conditions

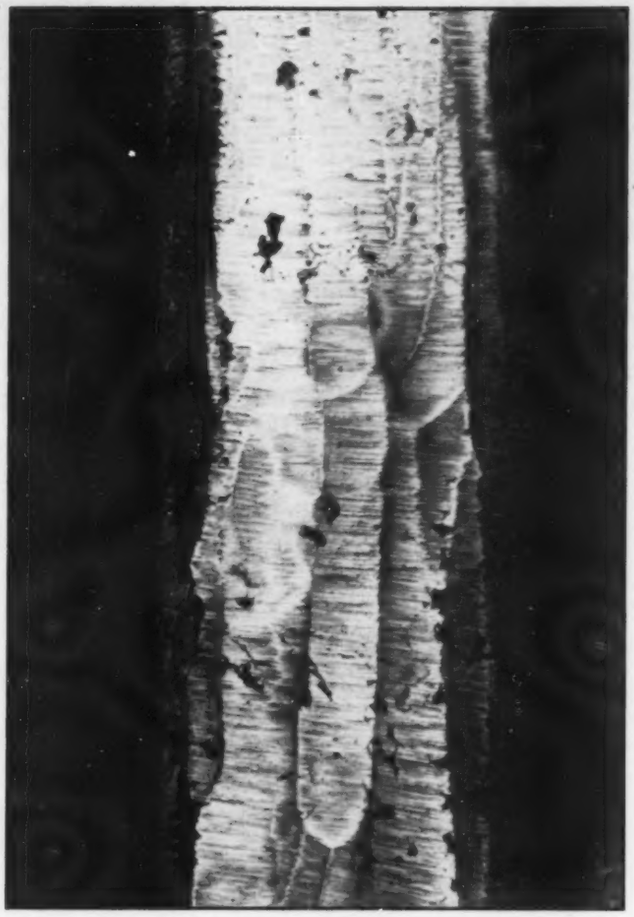


Figure 9 — Scabs due to turbulence in pouring.

by properly killing the heat. The amount and type of deoxidizers used, and the time and method of adding during final deoxidation of any steel is governed by the melting practice, the composition of the steel being made, and the characteristics required in the finished product.

6. Avoid ladle additions whenever possible since the depth of steel in the ladle is considerably greater, and the temperature is lower than it is in the furnace bath, which makes it more difficult to eliminate the inclusions formed.
7. The furnace bottom must be in good condition and the spouts, ladles, brick hot tops, and molds must be clean and dry. Warm brick hot tops will not spall during the pouring operation as easily as cold ones. Cover all molds except the one being poured. Avoid mold additions, mold coatings and materials for covering the molten steel in the hot tops that add gases and inclusions to the steel or affect its composition.
8. Avoid refractories that erode excessively and that contain quartz. The packing material in the ladle well should be of a composition that will not wash out during the pour. In general, uniformally burned fireclay refractories free from laminations, that have a low softening temperature, high density, with enough permanent expansion to assist in sealing cracks, and that will resist spalling and excessive erosion are desirable in ladle linings and nozzles. A refractory material that is more resistant to erosion and that will remain more rigid such as graphite or sillimanite is more suitable for sleeves. Some steelmakers are able to produce cleaner steel by using graphite sleeves, heads and nozzles. Successful pouring practice has also been obtained by using soft heads and hard nozzles. Magnesite is dense and highly refractory but it is not universally successful as a pouring refractory because of its poor spalling resistance. The main difficulty with magnesite nozzles is that the high thermal conductivity of the material leads to the formation of bugs and even closing of the nozzle, requiring frequent re-opening with an oxygen lance. Fireclay nozzles dipped in tar have been used successfully without cracking and bugging trouble. Nozzle composition and design should be developed for each grade or group of steels having the same pouring characteristics and practice.
9. Use the proper working, tapping and pouring temperatures.
10. Special attention must be given to pouring practice since it is one of the most important phases in steel making, which controls surface and internal quality.
11. Use a minimum size ingot. Small ingots produce smaller inclusions, less segregation and a finer crystalline structure. Hydrogen may also cause a serious internal defect known as flaking so that necessary precautions against this condition are taken by heat treating the steel, which begins when the ingot is stripped.

Faulty pouring practice is one of the most prolific sources of surface imperfections in semi-finished steel. There is probably no phase of steelmaking that varies more widely from plant to plant and is more of an art and less of a science than pouring practice. Good steel out of the furnace can be ruined as a result of poor workmanship in the pit, and rendered unsuitable for applications to orders where exacting surface and physical requirements are essential.

Slow taps cause skulling around the ladle nozzle which may result in bad pouring, while rapid taps cause an early slag and shorten the time for ladle additions. Heats tapped hot are held in the ladle to obtain the proper pouring temperature so that they will not be too hot but still hot enough to pour without a skull. Holding the ladle also aids in cleaning the steel from gas, refractory inclusions entrained during tap and inclusions produced by late additions. Holding in the ladle too long may cause a running nozzle which results in the most undesirable pouring conditions.

The development and control of the proper working and tapping temperatures which in turn determine the pouring temperature begins when the heat is melted. Due to activity of the bath during the oxidizing period the heat is transferred more rapidly and distributed more uniformally throughout the bath than during the deoxidizing period when the bath is mildly active. If the heat is cold at the end of the oxidizing period, then it is difficult to get the bath hot enough to insure clean steel and proper pouring conditions. Stirring the bath will decrease the variations in temperature to some extent during the deoxidizing period. When an ingot is poured cold or slow, its internal structure is fine and fairly uniform but the surface is rough and usually

contains scabs and blowholes, as illustrated in Figure 8 on a 7 in. square ingot of 2 per cent C-12 per cent Cr steel. On the other hand, an ingot poured hot has a smooth skin but has a more hetrogenous and tender structure which may cause cracks. A high pouring temperature will also act to form coarse carbides and columnar crystals, a condition which is undesirable on such grades as high speed steels. Both of these extreme pouring conditions will cause surface imperfections. It is difficult even for the most skilled furnaceman to judge the right tapping and pouring temperature from heat to heat, so that these extreme conditions occur occasionally. Recently bath immersion type pyrometers have been developed which show promise, and in the future, progress in melting may parallel the accomplishments made in heat treatment due to scientific temperature control.

The stopper-rod assembly requires specialized workmanship and careful drying following a definite cycle under temperature control. Each shipment of stopper heads should be sampled and tested for cracks to insure good pouring practice. The ladle and nozzle must be clean and dry, the stopper-rod must be properly set, and the mechanism for operating the vertical movement of the stopper-rod in the ladle must be in proper working order before tapping the heat.

In good pouring practice when a shutoff is made, it is necessary that complete closure is made between the stopper head and the nozzle to prevent leaks. In the case of fireclay nozzle and graphite head combination, when the ladleman applies pressure, the nozzle seat must deform until it assumes the contour of the head to obtain a perfect closure. If the nozzle is plugged up it should be cleaned out with an oxygen lance, but not over a partly filled mold during the pouring of the ingot or an empty mold that is prepared for pouring.

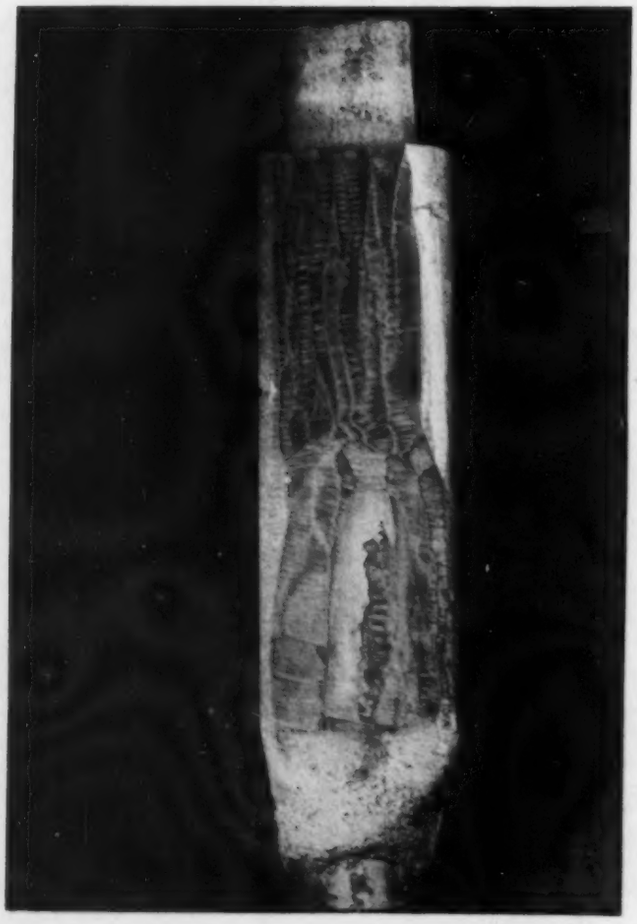
The difference in temperature of liquid metal from beginning and end of the pouring operation may be minimized somewhat by insulating the ladle and by a double nozzle arrangement in the ladle for pouring two ingots at a time.

Scabs are generally caused by the stream striking the mold wall, turbulence, fanning stream, splash caused by opening the nozzle too suddenly, slow pouring, stop pours, pouring off center, leaking stoppers and bad mold condition. Figure 9 shows scabs and cavities on a ground surface of a 7 in. square ingot of stainless steel caused by turbulence during pouring. Figure 10 shows a large deep scab on the bottom half of a ground 7 in. square ingot of stainless steel caused by the stream striking the mold wall. The degree of splash depends on the method of pouring and is a function of nozzle size, skill of the pourer, height of metal in the ladle, and height of mold. As a rule the practice is to open the nozzle slowly until a pool of metal is formed, which serves as a cushion in the bottom of the mold, thereby preventing a certain amount of splash when the nozzle is opened to a full stream. A more uniform stream may be obtained with a longer nozzle in that to some extent it prevents spraying and fanning of the stream. To obtain a uniform rate of pouring, the nozzle bore should increase as the ferrostatic head decreases. This is difficult to obtain in practice because during the pouring operation, erosion increases the nozzle bore which increases the pouring rate up to a point when about half of the heat is poured, followed by a decrease in pouring rate to the finish of the pour. Nozzle size is determined by the size of the heat, mold size, and grade of steel. A nozzle size may be chosen that will permit to some extent a filling rate rapid enough to enable the metal to overtake the splashes formed before they become too cold or oxidized, but the rate of pour cannot be so great that it will produce inferior internal soundness, tender structure, and the danger of cracking the ingot.

Pouring conditions are improved by decreasing the ferrostatic pressure which is largely a function of the size of heat and ladle and nozzle design. The velocity of the metal stream at the nozzle varies as the square of the radius of the nozzle bore, and the square root of the head of steel in the ladle which decreases during pouring. The ferrostatic head may be decreased by making the ladle shallow. Another method of reducing the ferrostatic pressure is by pouring through a basket or pot, as illustrated in Figure 11 which shows a heat of saw steel being poured through a graphite pot. The method overcomes the bad effects of a fanning stream and produces less splashing in the mold.

Top pouring while the cheapest and by far the commonest method is unfavorable since the impact of the liquid metal on the bottom of the mold causes splashing. Experiments in top pouring using various methods such as cardboard liners, diffuser cups, stove pipes, etc. have failed to make sufficient improvement to compensate for the added expense. While good surface quality can

Figure 10 — Large scab due to stream striking mold wall.



be obtained by proper precautions with top pouring practice, it is apparent that turbulence or splashing and metal rise in the mold can be controlled more readily by bottom pouring which produces superior surface quality more consistently. Figure 12 shows the bottom pouring practice used on a heat of saw steel.

From experience a mold temperature best described as "hand warm" gives the most satisfactory results. Cold, wet, rusty or dirty molds are difficult to coat and not only reduce mold life but induce surface reactions in pouring that result in scabs, porosity and seams on the semi-finished steel surface. Hot molds reduce mold life, burn the protective coating, and make it difficult to adhere.

Practically every melting shop has its favorite mold coating for improving ingot surface, and many types have been tried such as tar, talc, pitch, sugar, borax, graphite, aluminum, tar-aluminum and smoke. Tar, pitch, aluminum, smoke and tar-aluminum are most popular in tool steel shops. The selection of the type of coating and method of application is governed by many factors some of which are: composition of the steel poured, mold temperature, pouring temperature, rate of pour and mold size and design. The development of a suitable mold coat invoves long experimentation which is usually carried out by a trial and error method. The function of a mold coating is to overcome the effect of splashings and prevent undesirable material from sticking to the sides of the mold ahead of the rising steel, by creating a light boil resulting in a rolling action in the molten metal, without reacting with metal to cause ingot defects or reduce mold life.

The binding of ingots by hot tops is a direct source of cracks as shown in Figure 13 on a ground (magnafluxed) 7 in. square ingot of stainless steel. These transverse cracks which are referred to as hanger cracks are generally located near the top of the ingot. The condition may be corrected by using a "floating" type of hot top which allows freedom of movement of the ingot during cooling.

Tool steel is generally poured in big end molds, the design of which is determined by the grade of steel, method of pouring, ingot size and limitations of existing equipment. The mold is designed to obtain a rate of heat transfer from the molten ingot, that will give the maximum rate of solidification to produce a uniform structure with a minimum of segregation without excessively stressing the ingot or causing pipe. If a mold design causes great differences of temperature in the ingot during solidification, thermal stresses will develop that may result in external as well as internal cracks in the ingot, the severity of which increases with carbon and alloy content of the steel and ingot size. Other conditions in addition to mold design can also set up ingot surface tension stresses some of which are: a wavy surface in the mold chamber, high pouring temperature, too rapid a pouring rate, splashings, stickers, scabs, and dirty, fire-cracked or gouged molds. Figure 14 shows fine surface fissures on the bottom of a ground (magnafluxed) 12 in. square ingot of high speed steel caused by

Figure 11 — Ferrostatic pressure is reduced by pouring through a graphite pot.

a scabby condition. Some tool steelmakers grind the surface of the mold chamber to insure a smooth ingot surface. Figure 15 shows two 7 in. square experimental ingots poured from the same heat of carbon tool steel. The ingot on the left with the poorer surface was cast in a regular cast iron mold coated with smoke, while the ingot on the right was cast in a graphite mold. The surface of the mold chamber in each case was in good condition. The surface imperfections in the chamber of a graphite mold can be easily removed by filing and a high surface finish can be obtained with emery polishing paper. A properly designed corrugated or fluted mold chamber gives greater flexibility to the surface of the ingot, because of the increase in perimeter of its cross section which lessens the tendency to cracking. The flute radii are generally small to avoid surface cracks, but they must not be so small as to form laps in the hot working operation. The corners of square and slab ingots should be broad enough to avoid burning and decarburization during heating for hot working. The bad effects of splashing are reduced to some extent by designing the bottom of the mold with a curved contour, so that a pool of metal can be quickly formed to act as a cushion to the incoming stream of molten steel.

For internal soundness it is necessary that ingots are completely solidified before stripping. The time re-

Figure 12 — Bottom pouring generally produces better surface quality.

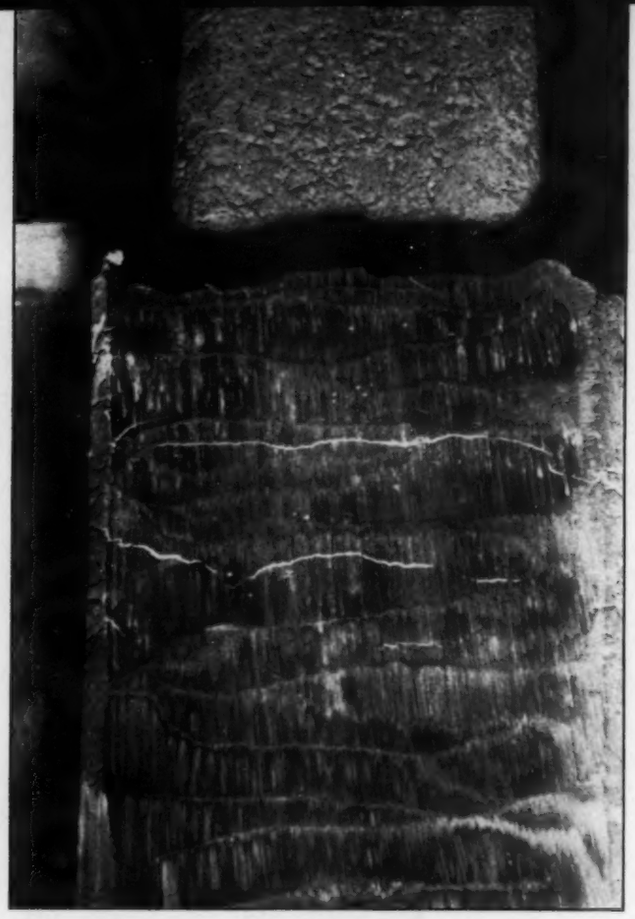


Figure 13 — Hanger cracks near top of ingot.

quired for complete solidification of an ingot varies approximately with the square of the minimum cross section. Leaving the ingot in the mold after solidification is completed shortens mold life by fire-cracking and may set up stresses in the ingot.

When the practice is to charge the ingot direct from the mold to the heating furnace for hot working, it is necessary that the furnace temperature at the time of charging is as close to the ingot temperature as possible, and that the temperature of the ingot is not below the critical temperature of the steel. The reason for this procedure is that the ductility of an ingot is poor because of its as-cast structure (which is composed of coarse crystals) and due to the stresses developed during solidification. This condition is even more severe on the higher alloy steels where the as-cast structure may also contain prominent columnar crystals. The highest ingot stresses are set up on air hardening steels where expansion due to martensitic transformation occurs even on slow cooling. Should the heating begin at too high a temperature on this type of structure, sudden expansion would crack the ingot because of the additional thermal stresses.

In shops that do not have the handling facilities for charging ingots direct from molds to heating furnaces, the ingots are cooled after stripping at a rate which is determined by ingot size and its composition. Small ingots of carbon and low alloy steels may be cooled by stacking in piles. Large ingots of medium alloy steels and all ingots of high alloy steels, and compositions susceptible to hydrogen embrittlement are slow cooled in fine ashes, lime, silocel, or slow cooling pits to prevent cracking. This practice also offers opportunity for a thorough inspection of the ingots. This is an important procedure since as a rule under normal hot working practice, the surface quality of the billet depends to a large extent on the condition of the ingot from which it is produced. Ingots with poor surfaces and of compositions that do not scale off easily during heating may be ground to insure more yield and better surface quality in the billet. In many cases it is difficult to determine the actual condition of the ingot surface from the appearance of its as-cast surface. It is only after removing the surface crust that the fine stress cracks can be revealed as shown in Figure 16 on a ground (magnafluxed) 7 in. square ingot of high speed steel. The annealing of ingots following slow cooling on air hardening steels make them capable of considerable plastic yielding, so that there is less danger of cracking during heating for hot working.

For good heating practice it is necessary to have temperature, furnace atmosphere and cycle control for each composition to avoid injury to the steel caused by overheating, uneven heating or overoxidation. The heating furnaces should be designed to obtain a uniform rate of heating efficiently, by using a fuel and method of firing that can be controlled, and equipped for a positive control of both temperature and atmosphere.

Overheating not alone induces excessive grain growth, but may also melt the more fusible constituents causing them to run out to the grain boundaries, resulting in intergranular weakness as illustrated in Figure 17. The

Figure 14 — These fine surface fissures were caused by a scabby condition on the ingot.

Figure 15 — The ingot on the right with the better surface was cast in a graphite mold while that on the left was cast in a regular cast iron mold.

billet is 6⅛ in. square, shown in two halves and contains 0.35 C-0.40 Mn-0.60 Si- 0.65 Cr- 0.60 Mo-0.55 Cu. The upper right hand end was overheated more than the rest of the billet causing penetration of the grain boundaries by copper. The small cracks throughout the surface were caused by the same condition of copper, while the scabs and large crack originated in the ingot. The two light gray defects in the lower half are forged in refractories, which may come from the roof or bottom of the heating furnace or where the brick hot top or the surface of the ingot was not properly cleaned off before charging.

Heating time which is governed by ingot size, composition of the steel and initial ingot temperature, should be gradual enough to avoid excessive differences of temperature that may cause overstrain by unequalized expansion during heating and variation in plasticity during hot working. In order to avoid cracking in heating cold ingots of alloy steel, which has a low ductility and thermal conductivity, it is necessary to preheat the steel gently for several hours up to 1200 F before raising the ingots to hot working temperature. Diffusivity, which is determined by the composition of the steel, governs the rate at which steel will absorb heat at a fixed temperature, and whether the steel is mild or sensitive will govern the rate at which heat should be applied to the surface of the steel. The manner in which heat is applied to the surface of the steel to be heated, which very largely reflects the design and method of charging and operating the furnace and the rate of fuel input, also affects the time of exposure and the rate of heating. Since it is inaccurate to estimate the internal temperature of an ingot or billet from measurement of its surface temperature, particularly if the surface temperature is changing, it should be determined for the various sizes and compositions by placing a thermocouple in the center of the steel and putting it through a controlled heating operation to obtain the time required for temperature equalization.

The temperature range during hot working must be under control to prevent surface defects and internal bursts. The correct temperature range at which the desired hot-workability is obtained cannot be simply selected from an equilibrium diagram, because it is not alone determined by composition of the steel but also by the practice by which the steel is melted. Most of the temperatures in use today in the hot working operations have been developed over a period of years by the tedious process of trial and error. Because of the variables involved, this temperature range is not always the same from heat to heat of the same composition. Some steelmakers use a hot twist test for determining the correct hot working temperature range for each heat of steel.

It is possible to scale away some of the shallow defects and decarburization from the surface of the ingot on low alloy tool steels in a controlled oxidizing atmosphere. Decarburization on the surface of the ingot takes place during solidification, the amount of which increases with ingot size. For example, from experiment on a 0.80 C low alloy saw steel, the depth of decarburization increased from an average of 0.03 in. per side

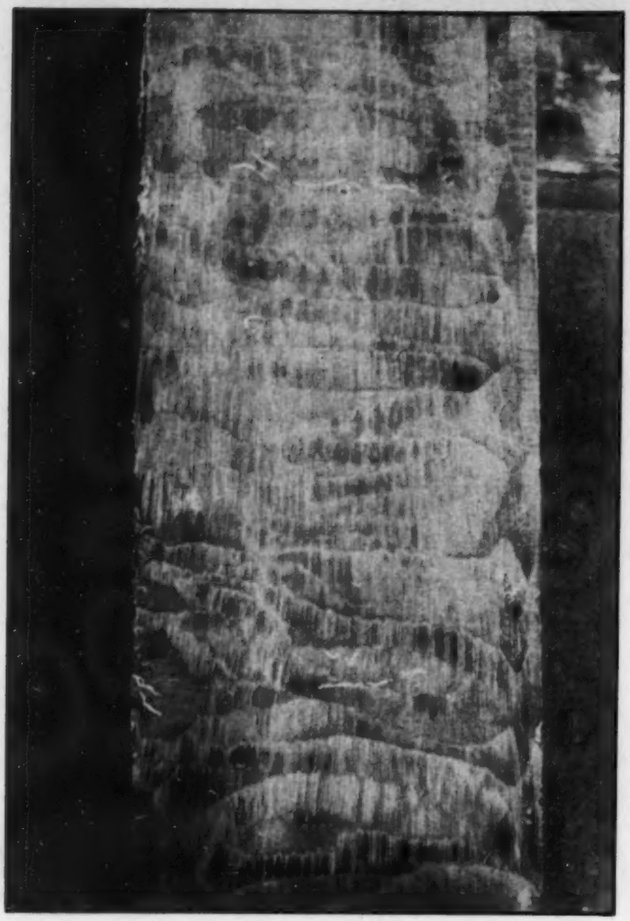


Figure 16 — Removal of the crust shows up the stress cracks.

on a 6 by 10 in. ingot to an average of 0.06 in. per side on a 9 by 16 in. ingot. Overoxidation of any steel and even low oxidation of some high alloy steels, leads to serious defects during hot working. Decarburization and scaling increase proportionally with the time the steel is exposed to the furnace atmosphere while at temperature. Decarburization may decrease on some steels with increase in temperature, providing scaling is heavy enough so that the oxidation of iron takes place as fast as the removal of carbon on the surface of the steel. Sulphur dioxide, oxygen, water vapor, and carbon dioxide are the most active decarburizing and scaling agents, and should be under control by maintaining the proper fuel-air ratio, furnace pressure, and fuel analysis.

In hot working, resistance to deformation increases with the amounts of carbon and alloying elements, and as the temperature above the critical temperature decreases. Ingots of high alloy steels usually require more than one heating to reduce them to billet size. Due to the fragile condition of the as-cast structure, the ingot must be given light reductions at the beginning on all the sides and corners. It is only after the steel has undergone some deformation, with its resultant crystallization, that it can withstand heavier reductions. Corner cracks as they appear may be gouged out during the forging operation. To avoid internal bursts in the making of high speed steel rounds, the steel may be forged into a square or octagon and then machined into a round, removing surface imperfections at the same

Figure 17 — Overheating may also cause holes due to melting of some of the constituents.

time. The billets on compositions susceptible to cracking, due to rapid cooling, are stress relieved immediately after the hot working operation by slow cooling in some insulating material or slow cooling pits.

In many cases, other causes besides the ones already considered may be responsible for surface imperfections. Some of these are: roll marks and nicks, overfills, too heavy a reduction, scratches caused by guides and strippers that may overlap, deep grooves from roll ragging carried over to finishing where insufficient reduction will not take out but may overlap, wrinkles caused by excessive spreading which result in cracks on edging, unequal drafts, too much belly in rolls, twisting in rolling, firecracked rolls, collar cuts rolling into seams and slivers, accumulated scale on rolls causing slivers, tears caused by high roll speed, cracks caused by rolled material being welded onto the rolls, and cracks caused by heavy hammer blows in the early stages of cogging. Sometimes the source of trouble is not immediately evident, and requires a thorough check of all the operations before the real cause is isolated.

Since the applications for tool steel products have grown more complicated and severe, and the quality requirements have become increasingly stringent, it has been necessary for the tool steelmaker to concentrate greater effort on the problems of surface and internal quality. The production of high quality semi-finished steel requires satisfactory performance in the melting, hot working, and conditioning operations. If any of these fall below standard, the deficiency will be reflected in quality of the finished steel. To prevent excessive surface conditioning cost and low yield, and also to maintain a high degree of uniformity in quality of both surface and internal soundness in the finished product, requires rigid control in melting, hot-working and conditioning operations. The standardization of practice based on accurate data and study is an essential procedure in quality control. Efficiency of the control system will largely depend upon cooperation, knowledge and technique of both the operating and technical personnel, as well as, on the type of equipment and the extent to which practice has been standardized.

DISCUSSION

PRESENTED BY

C. M. FITZPATRICK, Assistant Superintendent, Blooming Mills, Bethlehem Steel Company, Sparrows Point, Maryland

S. F. MAGIS, Steel Works Metallurgist, Henry Disston & Sons, Inc., Philadelphia, Pennsylvania

C. M. Fitzpatrick: I was very much interested in the discussion of the composition of the tool steels that you used. You mentioned using tungsten and chromium steel. I did not hear any discussion of silico-manganese tool steels. Do you use those?

S. F. Magis: We make a modified silico-manganese tool steel for punches, shear blades, chisels and knives. I believe you are referring to the performance of the silico-manganese chisels.

C. M. Fitzpatrick: Yes.

S. F. Magis: Because we use air pressures over 100 psi and chip steels up to 300 Brinell, the tungsten type of chisel gives us the best service under these conditions. The service performance of a chisel depends to a large extent on the care and technique used in forging and heat treating. The chisels should be stress relieved immediately after forging by slow cooling, followed by normalizing for refining the microstructure prior to hardening. Chisel failures are generally due to poor heat treatment, seams, decarburization or thumbnail cracks resulting from forging to cold.

C. M. Fitzpatrick: Our experience is with straight carbon steels, particularly low carbon, and we have used a lot of silico-manganese chisels.

S. F. Magis: The silico-manganese chisels give a good account of themselves when chipping the softer steels and especially at pressures below 100 psi. Under these conditions they may out-perform the tungsten type. The silico-manganese composition may be modified, by the addition of vanadium and molybdenum to overcome the tendency to grain growth and carbide precipitation, and by lowering the silicon below 2 per cent to increase toughness. Improvement in chipping can also be accomplished by grinding the cutting edge of the chisel to the angle best suited for the hardness of steel being chipped.

C. M. Fitzpatrick: Another thing I was particularly interested in was your comment on mold preparation. In the use of tar or lime do you find any inclusions of any of the materials used in mold preparations in the microphotographs of your finished steel?

S. F. Magis: We smoke our molds with acetylene gas, which is a convenient method of application and gives the best results. From my experience in both open hearth and electric melting I find that mold cleanliness, condition of surface in the mold chamber, and mold temperature is more important than mold coating in controlling ingot surface quality. In fact an improper type of coating or method of application may harm the ingot surface as much as a dirty mold. A mold coating that will offer protection to the surface in the mold chamber and that will assist in improving the surface quality of the ingot is desired. I do not know of any coating that can meet these requirements economically.

C. M. Fitzpatrick: We have had a lot of discussions on breaking axles on ingot trucks with stool stickers, and we do not use anything other than tar in our plant. I was particularly interested in the idea of mold slurries because in Gary I notice they are using a lime exclusively, and our metallurgical people will not let us use that.

S. F. Magis: Refractory materials such as clay slurries and slacked lime are likely to contaminate the steel with inclusions. Some years ago I had an experience with clay slurries on open hearth seamless tubing where the slurry was used for coating mold plugs to prevent stickers. The result was a material decrease in the number of stickers with an increase in bloom and round rejections. In some cases the refractory material was visible to the naked eye on the surface of blooms, while off the round mill it could be detected just beneath the surface of the rounds. The condition was cured at the time by coating the mold plugs with a mixture of graphite and molasses. I had a similar experience on gun barrels made in the electric furnace prior to the last war. In this case the high inclusion content in the bore of the gun resulted from washed out clay that was used in patching the ladles.

C. M. Fitzpatrick: You are not conscious of any inclusions in your finished product, in the microphotographs?

S. F. Magis: We have not encountered inclusions from smoke coating. Any coating that will evolve volatile matter or contains hydrogen in any form, always presents the possibility of forming blowholes during pouring. Steel may also be contaminated by too slow a pouring rate, pouring too cold, high ferrostatic pressure and other reasons mentioned in the paper and previous discussion. If all factors are under control except splashing there is still the danger of contaminating steel. Splashing exposes a large area of the steel to oxidation, which is probably the greatest detriment to surface quality causing surface imperfections and inclusions. During the last war I had an opportunity to make an extensive comparison between top and bottom pouring in electric and open hearth shops making armor plate under my direction. The bottom poured steel had less surface imperfections and inclusions because turbulence, splashing and metal rise was under better control.

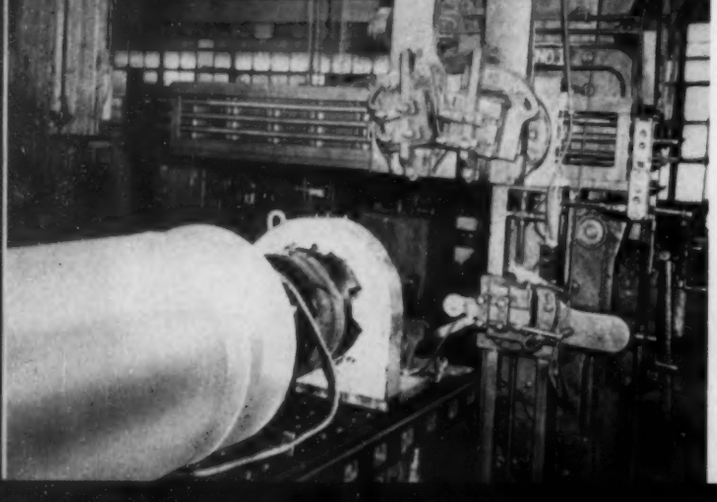
Maintenance Kink: ROLL GROOVING

A machine which will be of value to maintenance men in the steel industry is the idea of Virgil Jackson, foreman of the steel works machine shop of the Weirton Steel Company. This invention is a machine for rotating 40-inch blooming mill rolls on a planer for grooving or "ragging." The tool eliminates the use of an overhead electric crane to turn or rotate the roll on the planer bed; eliminates chatter when cutting grooves resulting in smoother cut grooves; and reduces the time per roll to about one hour and fifteen minutes, a saving of 75 per cent over the old method.

The planer operator is here setting up the machine to receive a blooming mill roll.

The operator is here cutting the groove. Note that the steel radius tool can be adjusted on the circumference without having to remove the tool each time for re-grinding. The cutter is always stationary on center while roll is rotated.

View of roll-unit and cutter in position.



Roll rotating machine.

CARBON HEARTH INSTALLATIONS AT HOMESTEAD

. . . . an operator's experiences with several designs of carbon block blast furnace hearth installations are here described . . . .

By C. J. FLEISCH, Superintendent, Carrie Furnaces, Carnegie-Illinois Steel Corporation, Munhall, Pennsylvania

▲ AT the present time, three partial carbon hearth installations have been installed in blast furnaces at the Carrie Furnace Plant of the Homestead District works, Carnegie-Illinois Steel Corporation. All three of these furnaces have been in operation for some time.

No. 1 furnace — Hearth diameter of 23 ft and rated at 931 tons per day. Blown in during December, 1945, and has produced 431,879 tons to September 1, 1947. See Figure 1.

No. 7 furnace — Hearth diameter of 23 ft 6 in. and rated at 971 tons per day. Blown in during July, 1946, and has produced 375,444 tons to September 1, 1947.

No. 6 furnace — Hearth diameter of 23 ft 6 in. and rated at 971 tons per day. Blown in during November, 1946, and has produced 264,450 tons to September 1, 1947. See Figure 2.

The details of the hearth and tapping hole construction and operating experience on these installations are as follows:

HEARTH CONSTRUCTION

No. 1 furnace — Starting from 12 ft 0 in. below the hearth elevation, there are seven courses of hearth and bosh quality blocks, then two courses of carbon blocks, and finally three courses of hearth and bosh blocks. All blocks are laid on end and each course rotated 45 degrees. The hearth and bosh blocks are 12 × 6 × 4 in., and the carbon blocks 12 × 8 × 4 in. The top of the hearth carbon blocks is 6 ft 0 in. below the center of the iron notch.

An eighteen inch ring wall of 18 × 11 × 4 in. straight and key carbon blocks is laid against the hearth coolers. This carbon ring wall starts at the bottom of the hearth carbon blocks and is carried up to the top of the hearth cooling jacket a distance of 11 ft 3 in.

No. 7 furnace — The construction here is similar to No. 1 furnace, except in the size of the carbon blocks and final courses of hearth and bosh blocks.

Starting from 15 ft 0 in. below the hearth elevation, there are ten courses of 12 × 6 × 4 in. hearth and bosh quality blocks, then two courses of 12 × 12 × 8 in. carbon blocks, and finally two courses of 18 × 9 × 4½ in. hearth and bosh. All blocks are laid on end and each course rotated 45 degrees. Again, the top of the hearth carbon blocks is 6 ft 0 in. below the center of the iron notch.

As in No. 1 furnace, the 18 in. ring wall of 18 × 11 × 4 in. carbon blocks is laid against the hearth coolers from the bottom of the hearth carbon blocks to the top of the hearth cooler, a distance of 11 ft 0 in.

No. 6 furnace — Starting 14 ft 6½ in. below the top hearth elevation, there are ten courses of 12 × 6 × 4 in. hearth and bosh quality blocks, laid on end and each course rotated 45 degrees as in the other furnaces. Then, two courses of large carbon blocks. The bottom course is cut from carbon blocks 15 ft 0 in. × 30 in. × 13½ in. The top course is cut from carbon blocks 15 ft 0 in. × 30 in. × 23 in. All blocks are laid at right angles to the center line of the iron notch. All joints are a 2 in. minimum and tamped with carbonaceous paste. Finally, there is one course of 18 in. × 9 in. × 4½ in. hearth and bosh blocks. From the top of the hearth carbon blocks to the center of the iron notch on this furnace is 4 ft 6 in.

Against the hearth coolers from the large hearth blocks to the top of the hearth coolers are two rings of carbon block, one inside the other. These blocks are about 30 in. × 28½ in. × 11¾ in., and form a carbon ring wall about 2 ft thick. Between the two rings of carbon is about 2 in. tamped with carbon paste.

In addition to the use of carbon in the construction of the hearth, both No. 6 and No. 7 furnaces were equipped with a one-piece solid carbon cinder notch liner to guard the under part of the opening, carbon being resistant to slag erosion and not subject to slag or gas corrosion. For these same reasons all three furnaces were protected by a ring of carbon brick around the cinder notch and around all tuyere openings.

TAPPING HOLE DESIGN

The tapping holes on these three furnaces are constructed of special shaped fireclay brick. In an attempt to improve the tapping holes a new design was tried. These tapping holes are similar with the exception that the one on No. 1 furnace, see Figure 3, was made from larger brick shapes than No. 6 and No. 7.

We believe there are several advantages of this new type tapping hole. The first is the simplification of its construction and the increase in strength obtained by the use of large brick shapes rather than the ordinary sized bricks. Whereas the old style tapping hole allowed a very small variation in the angle of drill, this one allowed a comparatively large amount. This is a matter of considerable importance, especially when drilling up for casts following a blow-in from a banking period.

Presented before combined meetings of the Eastern States Blast Furnace and Coke Oven Association and the Blast Furnace and Coke Oven Association of the Chicago District.

On No. 7 furnace we experienced a breakout around the tapping hole during a cast ten months after the furnace was blown-in. It was found that about one-third of the iron notch cooling stave insert had been destroyed, however, the hearth wall brickwork seemed intact and the iron notch opening was small and well defined. All indications were that the disturbance was entirely external. Contributing factors were the facts

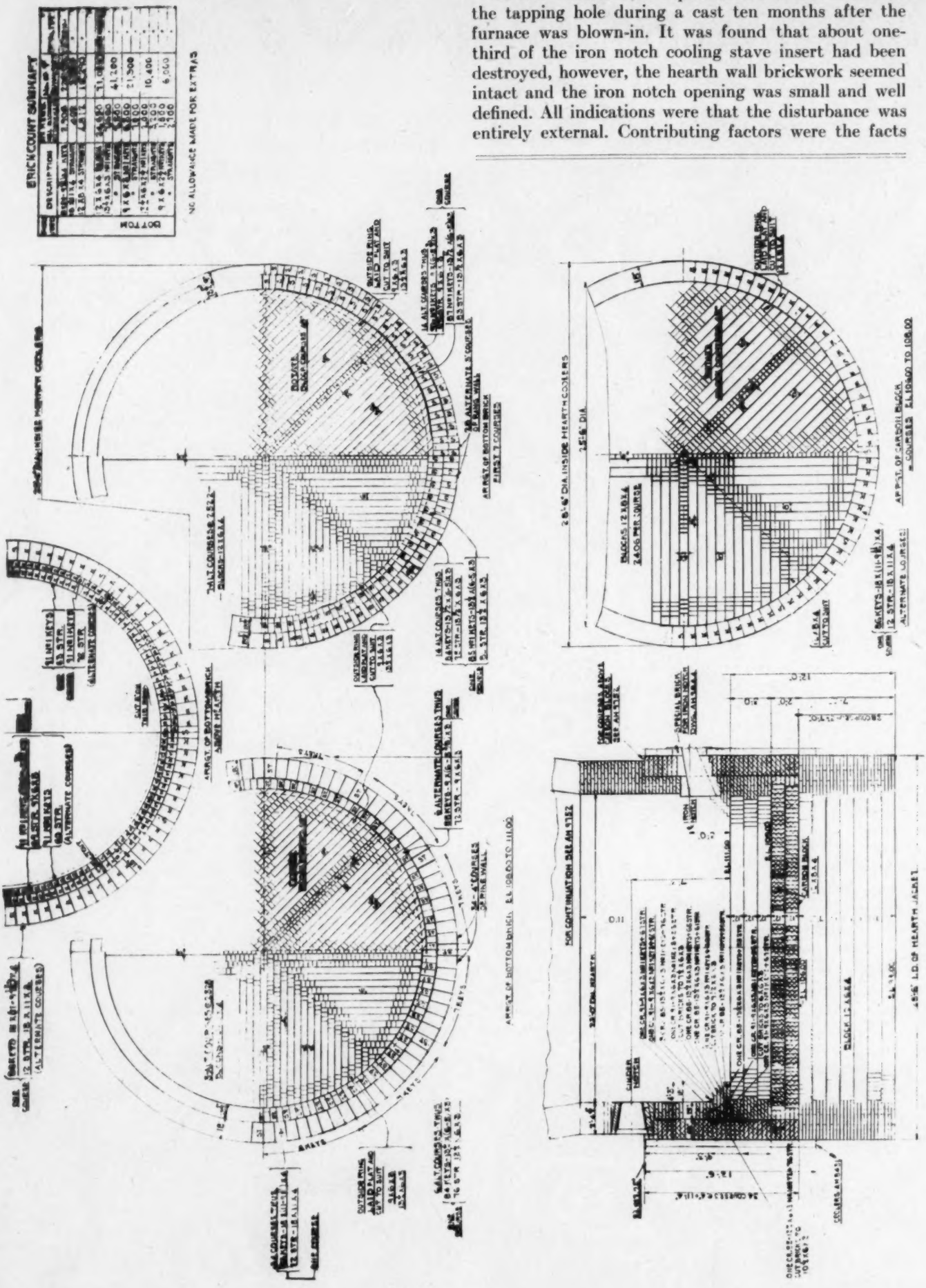


Figure 1 — Blast furnace No. 1 has been in operation for two years since the carbon hearth was installed.

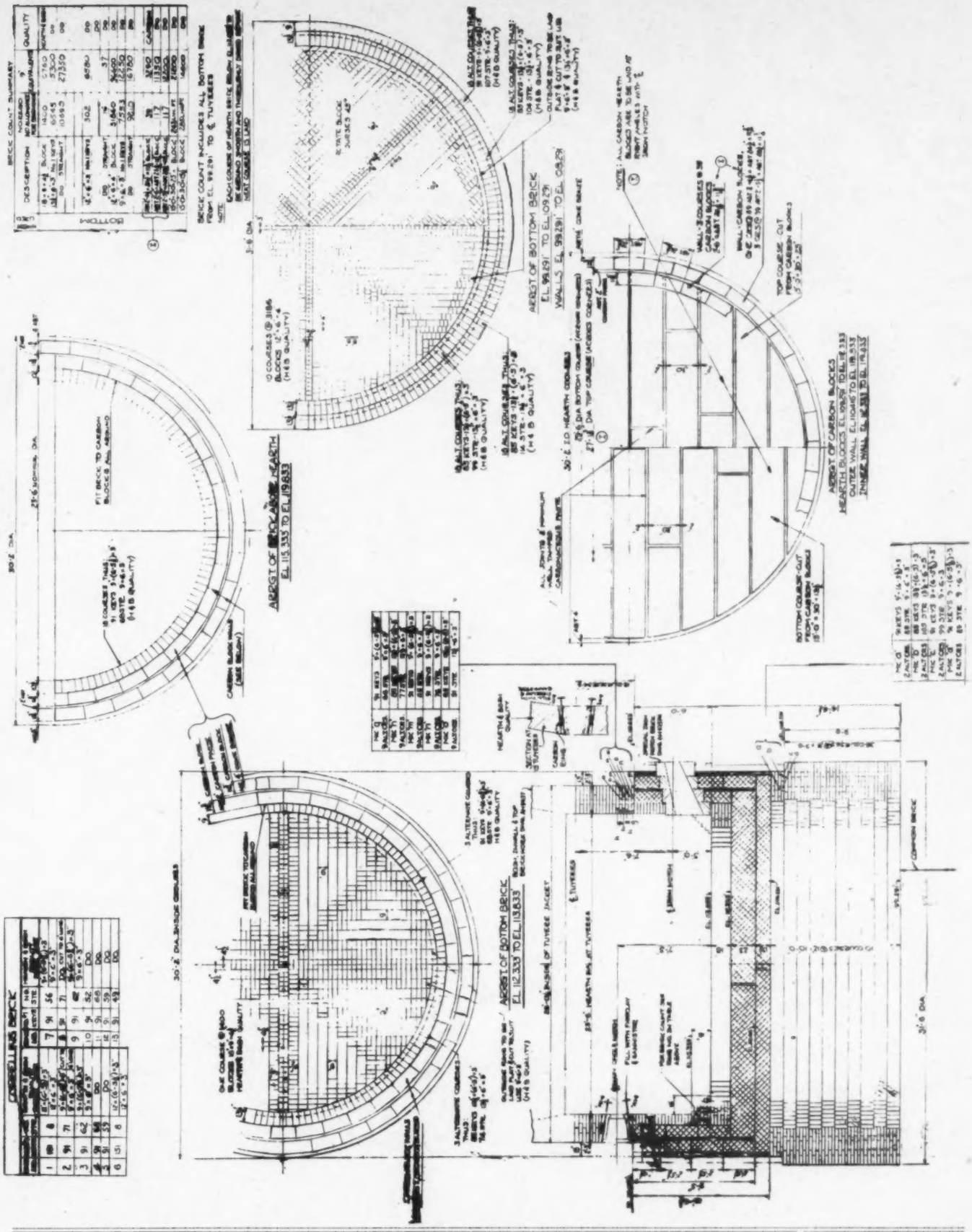


Figure 2 — The later designs use larger size carbon blocks.

that while special iron notch fireclay shapes were used, there was still an unbroken vertical joint through the iron notch at the adjoining face of the hearth wall and cooling staves; also the fit of the cooling staves to the hearth jacket at this point was very poor, which necessitated the opening being filled with grout.

Our experience on the No. 1 and No. 6 installation has been very satisfactory. No apparent breaking up of the hole has yet been noticed, so from all indications, they are still in good condition. The new type hole does not seem to make much difference in the number or size of coke messes, other than it seems to make it

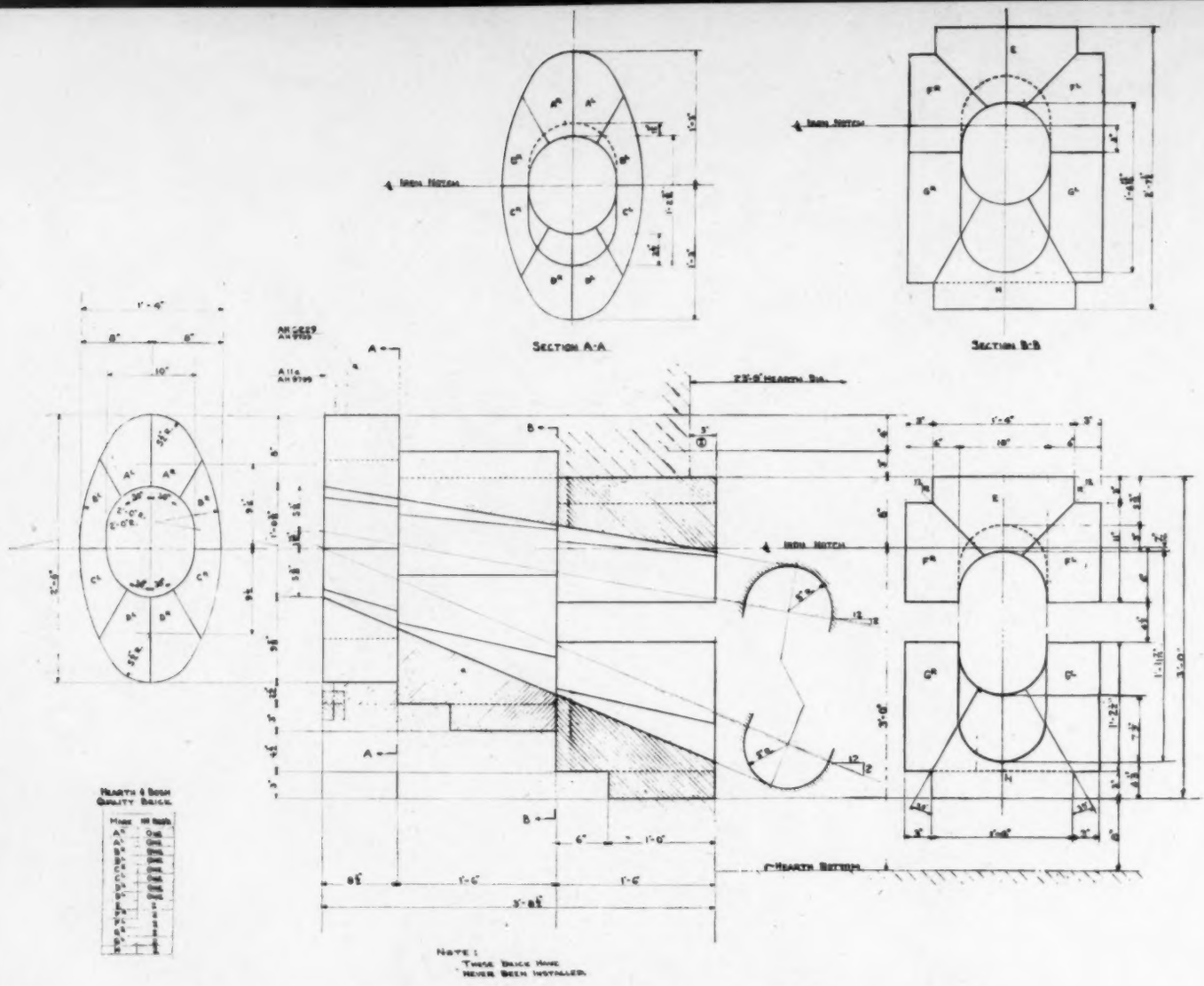


Figure 3 — A special brick, used in the tapping hole of No. 1 furnace, is here shown.

easier to maintain the length of the tapping hole. Very few "short holes" have been observed to date.

OPERATING HISTORY

It has been our experience that the size of casts on furnaces with carbon hearth has been more uniform, this has been particularly true of No. 6 and No. 7 furnaces, also that the iron analysis takes more abrupt swings from cast to cast; we feel this is due to the lack of the cushioning effect of the large pool of iron in fireclay block hearths. We have further noticed that if a carbon hearth furnace gets "cold" in the hearth for several casts, it takes more coke to restore the proper hearth temperature.

While thermocouples were not installed in any of the three installations, it is indicated by the hearth cooler discharge water temperatures that the loss of hearth heat to the cooling water has been higher, with the highest temperature being on No. 6 furnace where the large carbon blocks were used, this temperature running 5 to 6 F higher than those on fireclay installations.

There has been no change in our flushing or tapping practice between carbon and fireclay installations, these practices being the same on all furnaces. We have experienced some trouble on No. 1 furnace with iron in the slag, however, this furnace has a tuyere directly over the cinder notch which could contribute to this trouble. No. 6 and No. 7 furnaces are normal in this respect. No conclusive iron temperatures have been taken; however, a few temperatures taken with an optical pyrometer showed no difference from those taken on furnaces with fireclay block hearths.

Another item which may be of interest was our experience coming in off of bank following a recent shut down. Five furnaces were banked for approximately eight days. The two furnaces with fireclay block hearths, No. 3 and No. 4, gave more trouble and took a longer period to make iron which was acceptable to the open hearths. No. 4 furnace sending iron on the eighth cast and No. 3 on the ninth cast, while in comparison the carbon hearths No. 1, made acceptable iron on the third cast, No. 6 on the fourth cast and No. 7 on the second cast. While this may not be a fair comparison due to the life of the No. 3 and No. 4 furnaces it is interesting to note. Also the fireclay block hearths skulled up on the hearth walls to a greater extent, causing trouble in getting a proper flush from the monkeys. It took approximately twice as long to get a satisfactory flush from the fireclay block hearth furnaces as it did on the carbon hearths.

The AISE Kelly Awards

▲ THE 1946 prize winning Kelly Award papers were announced at the 1947 annual convention of the Association of Iron and Steel Engineers. Ross E. Beynon won the first prize for his paper, "Rail Mills and Rail Mill Design," as the best paper published in 1946 in the *Iron and Steel Engineer*. This is the fourth time that Mr. Beynon has won a Kelly award, as he has placed in each of the four years since the contest was started. Second place went to Frank Janecek, blast furnace engineer, Republic Steel Corporation, for his paper, "Blast Furnace Operation Under Elevated Top Pressure." R. E. Dienst, production and cost analyst, Great Lakes Steel Corporation, won third prize for his paper, "Aid to Control of Open Hearth Practice by Statistical Methods."

Mr. Janecek's paper was one of the first on the subject of blast furnace operation under top pressure, a type of operation which promises many advantages and in the development of which, his company has been in the forefront.

The application of the science of statistics in attaining quality and economy in open hearth operation was the subject of Dienst's prize winning paper. The use of statistics has been found an invaluable aid in reaching this objective.

Nine papers have won awards in the previous three years of the contest. First place in the 1945 Kelly award was given to H. F. Lesso and R. W. McCann of the Great Lakes Steel Corporation for their paper, "Influence of the Charge upon Open Hearth Furnaces." This paper, published in the October, 1945, *Iron and Steel Engineer*, gives extensive data on the character of the charge materials entering the furnace charge, and evaluates the effects of variations in the charge upon open hearth performance. Specific values for the data are given in an extensive series of curves.

Ross E. Beynon was awarded second place in the 1945 contest for his paper, "Structural Mill and Structural Mill Roll Design," which was published in the February, 1945, *Iron and Steel Engineer*.

Ross E. Beynon, superintendent of roll shops, Carnegie-Illinois Steel Corporation, South Chicago works, is a four-time winner of Kelly Awards.

B. M. Larsen and C. Siddall of the United States Steel Corporation research laboratory at Kearny, New Jersey, were awarded third prize for their paper, "Theoretical Limiting Efficiency of Various Fuels in the Open Hearth."

The 1944 Kelly award was awarded to Ross E. Beynon for his paper, "The Rolling of Semi-Finished Steel." "Ferrous Electric Welding," by D. Bruce Johnston, assistant to the Research director, Lukens Steel Company, Coatesville, Pennsylvania, was awarded second place. Third place for 1944 was given to "Bearing Metals in the Steel Industry," by Samuel Epstein, development and research engineer, and Richard C. Hess, experimental engineer, Bethlehem Steel Company, Bethlehem, Pennsylvania.

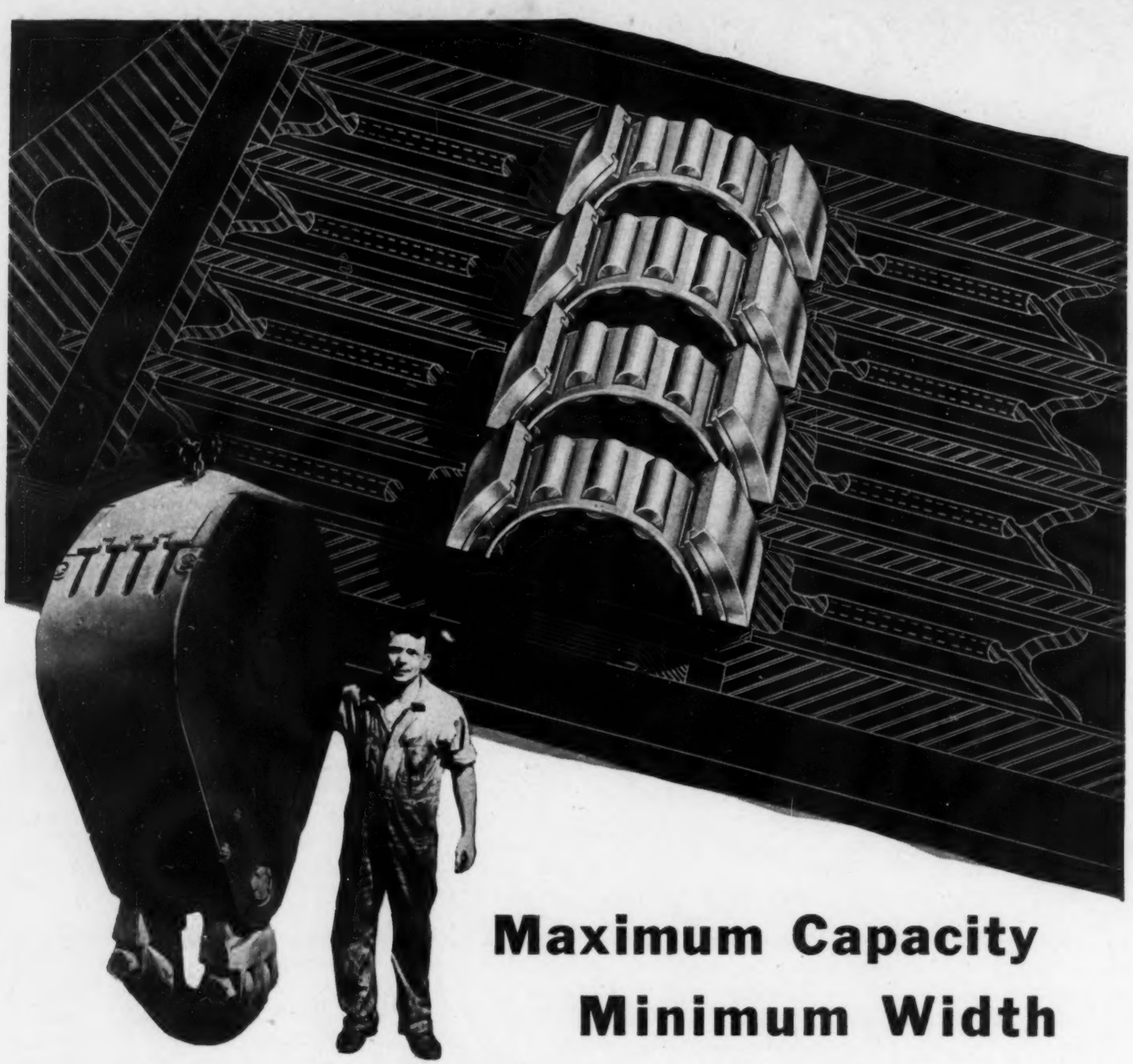
The first Kelly award was won by Mr. A. J. Fisher, fuel engineer, Bethlehem Steel Company, Sparrows Point, Maryland. This award was given to him for his paper, "The Relation of Flame Character to Open Hearth Operation," published in the May, 1943 issue of the *Iron and Steel Engineer*.

When the first award was originally made, only one prize was given. However, later action by the Board of Directors established three awards for each year, and consequently, it was later announced that second prize in the original 1943 Kelly award was given to Ross E. Beynon for his paper, "Bar Mills and Bar Mill Roll Design." Third place for the best paper in the 1943 *Iron and Steel Engineer* was given to A. D. Howry, electrical engineer, at that time for the Alan Wood Steel Company, Conshohocken, Pennsylvania, for his paper, "Application of Mercury Arc Rectifiers in Steel Mills."

The Kelly award carries prizes of $300, $200, and $100 for first, second and third place respectively. The award was established September 28, 1943, to honor John F. Kelly, Managing Director of the Association of Iron and Steel Engineers from 1917 to 1934, and to perpetuate the memory of his achievements in the advancement of the Association.

RULES OF AWARD

1. The Award shall be given annually to the author of the paper, adjudged of greatest value in the advancement of engineering or operating practice in the iron and steel industry.
2. The entries for each judging shall be the papers published during each calendar year, although some may have been presented at meetings in the previous year. Voluntary contributions of papers not presented at meetings but published by the Association are also included in the judging.
3. To be eligible for the Award, the author must be directly employed in the iron and steel producing industry. The author need not be a member of the Association of Iron and Steel Engineers.
4. The Award shall be made at the Annual Fall Meeting following the close of the calendar year.
5. The Award shall be made by the Board of Directors of the Association on the recommendation of the Executive Committee of the Association.



Maximum Capacity Minimum Width

Streamlined shape and rugged construction speak for the stamina of this new McKissick Traveling Block. But a look inside, where four Hyatt Roller Bearings carry a 200-ton load, shows how the bearings contribute to highly efficient design and operation.

These bearings are Hyatt Hy-Load Type, which feature high radial capacity for minimum bearing width—making possible the narrow sheaves for block compactness which, in turn, permits maximum derrick working space.

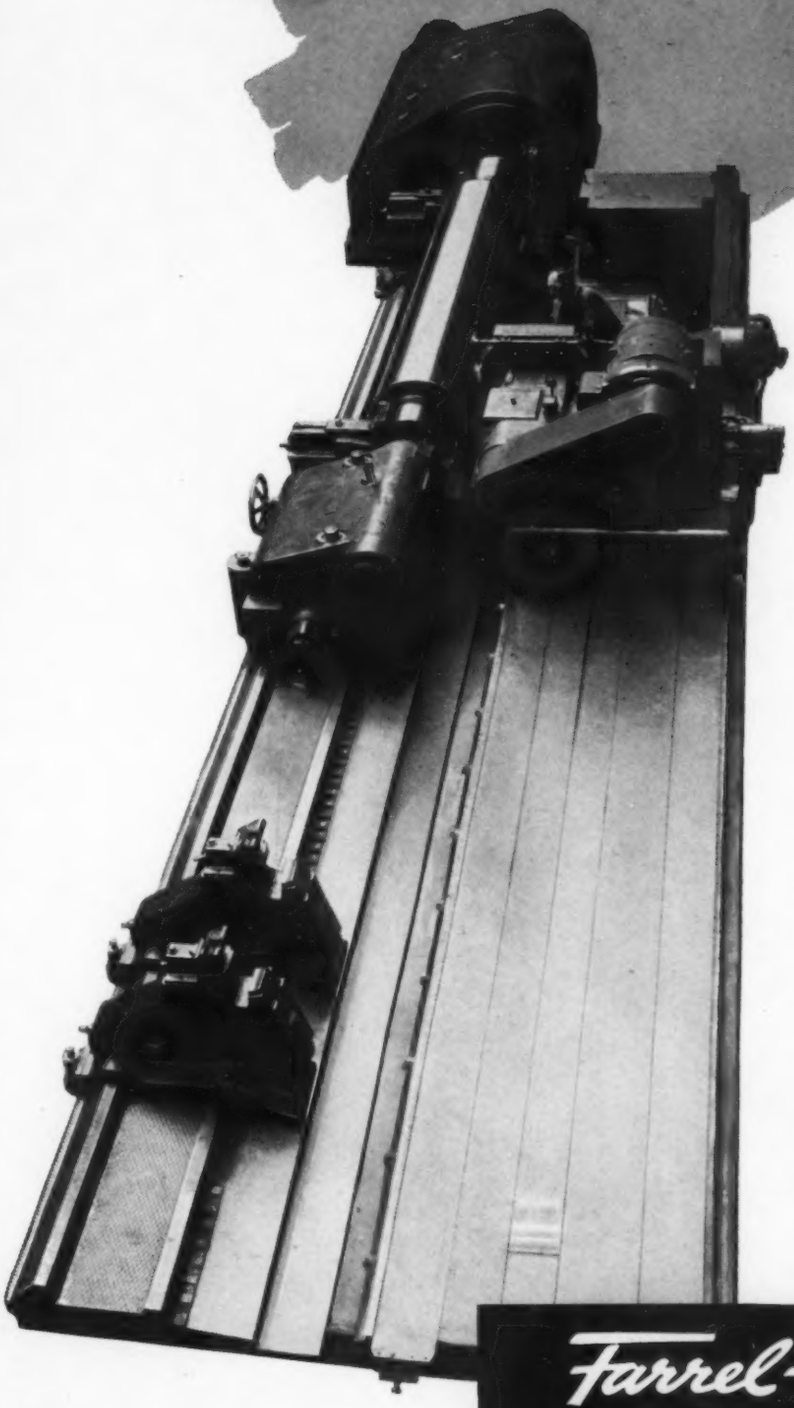
The bearings are used without inner races, the rollers operating directly upon the hardened surface of the pin. Three advantages result: larger pin size for given bearing rating—easier assembly because there are no inner races to apply—better lubrication.

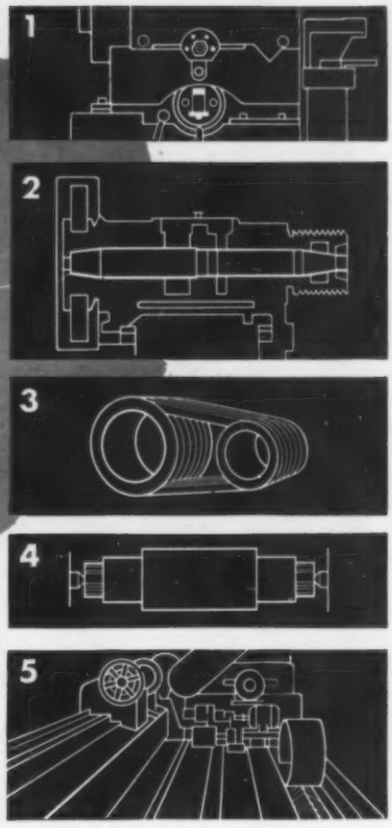
Wherever Hyatts are used you'll find sweeter design and sweeter performance, like this. It's a combination that has won for Hyatt and Hyatt customers millions of friends not only in the oil field, but in mining, transportation, agriculture, construction, and throughout all industry.

It will pay *you* to look into the advantages of Hyatt Roller Bearings for your product, and Hyatt Engineering Service is available to help you do it without cost or obligation. Write to Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

WHAT GIVES THIS 60" ROLL GRINDER AUTOMATIC PRECISION





Five important design features that contribute to automatic precision in this big Farrel grinder are:

1. AUTOMATIC CROWNING AND CONCAVING DEVICE—This built-in "brain" automatically produces a mathematically accurate curve for either a crowned or concaved roll, with both halves perfectly symmetrical. The same setting invariably produces exactly the same curvature.

2. GRINDING WHEEL SPINDLE—Of large diameter for rigidity under working load—made of high grade alloy steel, heat-treated and precision ground—mounted in adjustable bearings, automatically lubricated.

3. WHEEL SPINDLE AND HEADSTOCK DRIVES—Work and wheel are both driven through multiple V belts. Their smooth, vibrationless transmission of power safeguards precision.

4. TWO DEAD CENTERS—Dead center in the headstock as well as in the footstock insures concentric rotation of the work, which contributes to precision grinding of journals and bodies.

5. INVERTED V WAYS—Cast separately from the bed, of a special grade of alloy iron, they are exceptionally resistant to wear, maintaining their accuracy for a long life. Automatically pressure-lubricated and covered by flexible metal guards to exclude dirt and grit.

Farrel roll grinders are available in two types—Type HD shown here, and Type TT which has a traveling work table. Complete details of either type will be sent promptly on request.

FB-366

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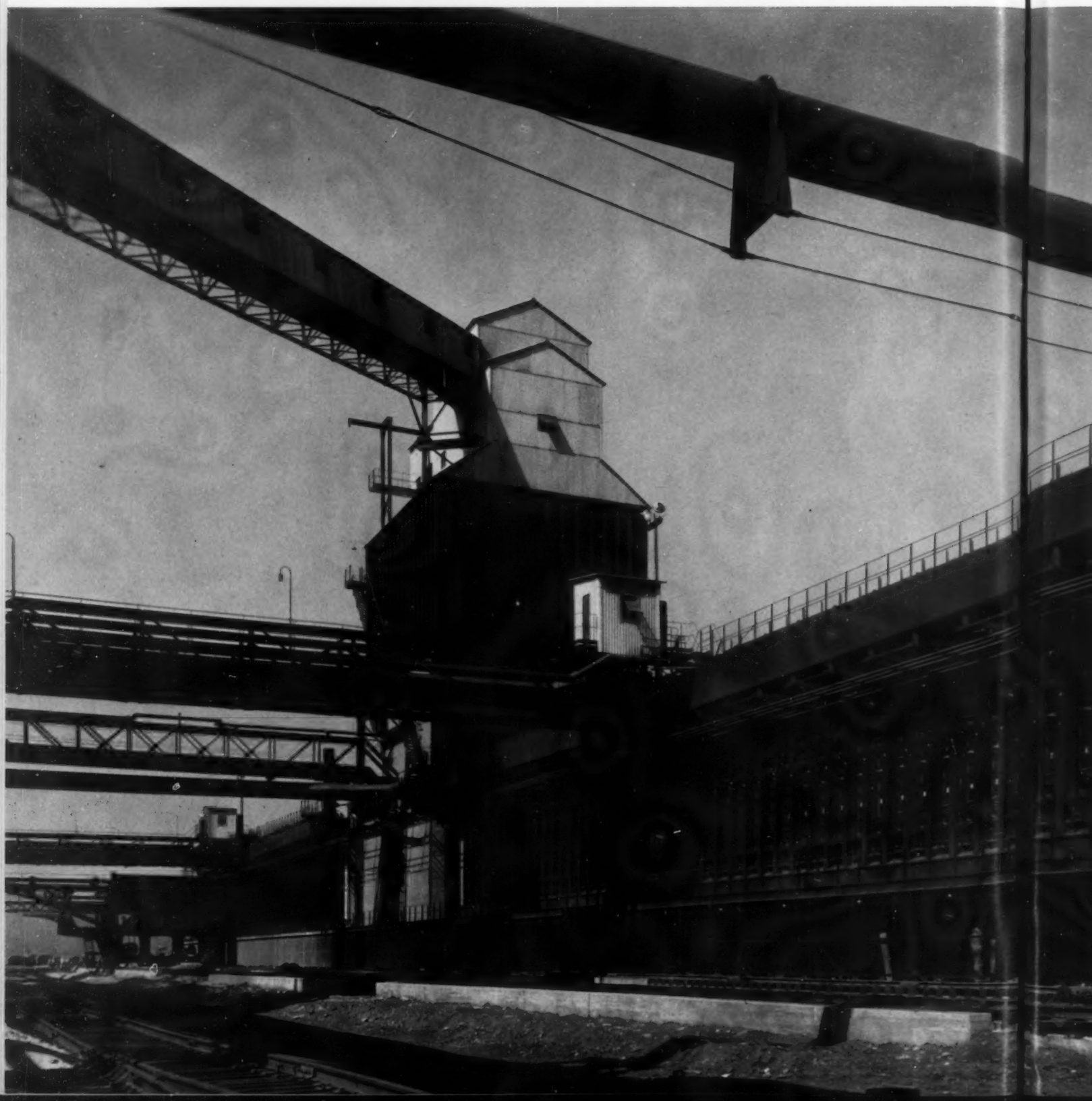
KOPPERS COMPLETES COKE OVEN PLANT EXP



T EXPANSION FOR WEIRTON STEEL COMPANY

TWO BATTERIES—106 NEW OVENS ADDED

Koppers has recently completed construction of two batteries totaling 106 Koppers-Becker Ovens for the Byproduct Coke Plant of Weirton Steel Company at Weirton, West Virginia.

These latest batteries are Koppers-Becker Under-Jet Ovens equipped with Waste-Gas Recirculation and Blast-Furnace Gas Underfiring equipment.

The first of these two newest batteries was put into operation on July 19, 1947, and the second was started on September 10, 1947. They are rated to carbonize approximately 2600 net tons of coal per day.

Koppers engineers designed and constructed the first battery of byproduct coke ovens operated by Weirton in 1922, and since that date, Koppers-Becker byproduct coke ovens have been used exclusively in this plant for the production of blast-furnace coke.

Since the erection of the 37 initial ovens in 1922, the following repeat orders were received:

1925— 49 ovens
1929— 25 ovens
1941— 45 ovens
1946—106 ovens

The first four batteries of ovens were built in line, the fourth battery being built on a unique foundation which extended out over the river bank for a considerable distance. This foundation made it possible to build the battery in line with the other three batteries, saving the investment in much duplicate auxiliary equipment.

The two new batteries of ovens were built on a site adjacent to the older batteries.

The Koppers engineering staff specializes in the design and construction of the most advanced and efficient coal carbonization, material handling and gas treatment equipment.

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KOPPERS BUILDING, PITTSBURGH, PA.

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Practical, workable rolling mill designs, engineered and produced by an organization which understands your requirements is your best guarantee of a satisfactory installation. Continental's specialized experience in rolling mills and equipment merits your *first* consideration.

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ROLLS • STEEL CASTINGS

The Pittsburgh Steel Foundry Corp.

OF GLASSPORT, PA.

• . . . does a 100 hour job in 44 minutes

AIRCO TECHNICAL SALES SERVICE REPORT

PROBLEM: To remove this 52-inch, 7-foot high riser from a 50-ton cast steel anvil block.

SOLUTION: We recommended cutting with an Airco No. 40 Radiagraph equipped with a Style 6740 water-cooled torch. Two cuts were made; the first five inches from the finish line. Then, after inspection (no defects were visible), the second and last cut was made one inch from the body of the block. This entire job was completed in 44 minutes.

Pittsburgh Steel Foundry Corp. estimates flame cutting to this close tolerance permitted a saving of approximately 100 hours machining time.

R. J. Helmstaedt

Airco Technical Representative

Airco's Technical Sales Division is at the call of all industry in applying Airco processes and products in the solution of their problems. If you have a metal working problem, ask to have a Technical Sales Division man call. Address: Dept. IS 6910, Air Reduction, 60 East 42nd St., New York 17, N. Y. In Texas: Magnolia Airco Gas Products Co., Houston 1, Texas.

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Literature

Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

ELECTRO-ALLOYS DIVISION OPENS MODERN HIGH ALLOY FOUNDRY AT ELYRIA, OHIO

▲ Electro-Alloys division of the American Brake Shoe Company announced the opening of its new $3,000,000 high alloy foundry at Elyria, Ohio. This foundry combines the finest equipment, layout and casting methods known to the high alloy casting industry.

The present success of high alloy castings has been largely due to years of intensive research — in which Electro-Alloys and the American Brake Shoe Company have played a leading part since 1919. The knowledge and experience accumulated during these years have now been brought together and combined with the most modern high-alloy foundry facilities in the world at Elyria, Ohio.

High alloy castings begin in the laboratory and are never released from full laboratory control. Before any start can be made, the physical characteristics of various chemical analyses have been established. The best and strongest metallurgical compositions have been developed to produce sound, uniform castings at the lowest cost. This calls for complete metallurgical research facilities.

Ground was first broken for the new Elyria plant in September, 1945. Construction was completed in July, 1947. The new plant has over 150,000 sq ft of floor space. All construction is of steel and brick with generous use of glass block throughout. The roof is monitor type covered with precast concrete slabs.

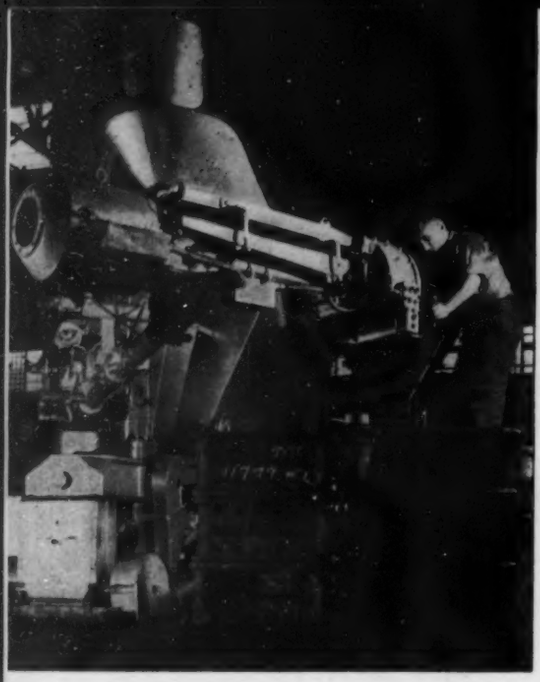
Particularly striking features of the foundry building apart from the great size of the foundry floor, 460 × 280 ft, are the even diffusion of light to all parts of the building, and the tunnels, pipes and conveyor systems for sand handling and dust collecting equipment beneath the foundry floor.

Mechanization is as nearly complete as practicable in an alloy foundry producing miscellaneous sizes and shapes of castings. Sand conditioning equipment is located in the center of the foundry. Conditioned sand moves overhead on a continuous belt conveyor delivering to hoppers at 18 molding stations along the route to each end of the building. After the mechanical shakeout, the sand moves underground back to an elevator which carries it up to the conditioner again.

Equipment located in the molding department includes jolt rockover molding machines; jolt squeeze strip molding machines; jolt squeeze molding machines for snap molds; floor jolt molding machines and, a sand-slinger in the center of the foundry which is available for larger castings. Gravity roller-type conveyors are conveniently located to take molds away from molding machines.

Equipment in the core room in-

Tapping a heat of Thermalloy from one of the three, top charge, hydraulically controlled electric arc melting furnaces.



Ramming a large floor mold with a sandslinger.

cludes bench jolt machines, core blowers floor jolt machines for large cores and a sand conditioning unit separate from that for the molding department. Rack type ovens and a car type oven all electronically controlled handle core baking. Large cores are handled directly from the core department to the mold set-up floors.

The most efficient possible ventilation has been provided in the plant. Dust-laden air is removed by hoods over and under each shakeout, and delivered to five hydroclones where the air is thoroughly washed and returned to the shop. The sludge is deposited in two floor tanks from which it is removed regularly.

Three electric induction melting furnaces (200 lb, 1000 lb and 2000 lb capacity top charge) and three top charge, hydraulically controlled electric arc melting furnaces (1000 lb, 3500 lb and 10,000 lb) are located in the center of the foundry. These six furnaces supply metal to any point in the foundry with minimum time and travel. An automatic electrical installation controls the furnace operations.

With such a flexible furnace department there is no delay in the production of either small or large special analysis castings. Close chemical analysis control as well as melting flexibility were the primary considerations in the choice of equipment and layout of the melting department.

Founded in 1902, American Brake Shoe Company, with its ten divisions and four foreign subsidiaries, operates a total of 60 plants, over 40 of which are foundries.

The six furnaces shown can melt from 200 to 12,000 lb of alloy per hour.

SHEET & TUBE TO EXPAND COKE CAPACITY IN CHICAGO

▲ Youngstown Sheet and Tube Company has authorized an immediate expansion of coke production in the Chicago district. Contracts will be awarded for construction of 75 additional coke ovens at the Indiana Harbor plant, increasing production about 35,000 tons per month.

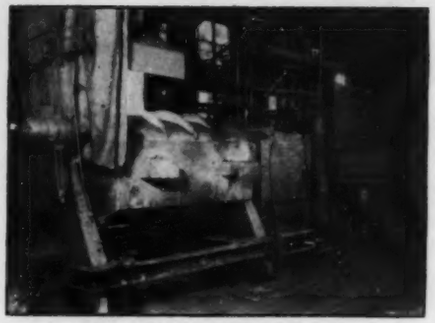
The expansion will balance the coke supply with increased pig iron capacity in the Chicago area. One of the Indiana Harbor blast furnaces will be rebuilt next spring and increased from 800 to 1400 tons per day.

HEATED METAL MIXER MAKES THIN CASTINGS

▲ Iron foundry operators have been looking for years for a holding furnace or forehearth which would serve not only as a mixer for cupola metal, but also eliminate the loss of temperature which occurs with the usual receiving equipment.

Whiting Corporation has developed a new pulverized coal fired unit, known as the "Whiting Heated Metal Mixer" which fills the urgent need of the foundry making small thin-sectioned castings. It is especially valuable where such castings are made on a production basis and molds are poured continuously on a moving conveyor.

Westinghouse Electric Corporation's "foundry of the future" at Trafford, Pennsylvania, has two of these furnaces in use and is successfully pouring very light castings on a continuous basis. Metal is transferred from the cupolas in a top-pour ladle to the heated metal mixer, which is located adjacent to the mold conveyor. Metal temperatures are maintained and even somewhat increased above that of the cupola metal. Composition is held remarkably uniform and adjustments may be made in the furnace if desired. Refractory lining is standing up very well. Slightly more than one ton of hot metal is being poured per hour although the equipment is rated at two tons per hour.



The heated metal mixer is a small portable tilting furnace.

The heated metal mixer holding capacity 6000 lb may be described as a small portable tilting furnace which is fired with pulverized coal from a No. 1 pulverizer. The pulverizer has a capacity of 100 lb of coal per hour. The tilting mechanism is operated by a pendant push-button control unit. The overall floor space requirement is 8 ft × 28 ft.

This newly developed equipment will produce continuous metal of uniform composition at a temperature sufficient to pour very light, thin-sectional castings, and should prove a valuable addition for any foundry making this type of work.

NATIONAL TUBE PUSHES COKE FROM LORAIN OVENS

▲ When white-hot coke was pushed from the new ovens at the Lorain, Ohio works of National Tube Company recently, it marked the completion of the first step in a huge modernization and expansion program to improve production facilities at this U. S. Steel plant.

The new coke plant is composed of three batteries of 59 ovens each with a total rated annual capacity of 800,000 net tons. These ovens, which

are of Wilputte design, will increase the total plant capacity to 1,650,000 tons.

In addition to the batteries, new coal and coke handling equipment, machinery and auxiliary equipment of the most modern design have been installed. Included are rotary car dumpers, mixing bins, and conveyors. Also, many improvements have been made in the coal chemical plant.

Other important projects either completed or under way at the Lorain plant include the construction of a new continuous seamless mill, a blooming, bar and billet mill, a new bessemer steel plant and a three-acre warehouse.

Structural work on the new seamless mill, which will make small size pipe, is now under way. The design of this mill is entirely new and constitutes a major innovation in pipe making. Sizes of pipe will range from 2 to 4½ inches and much of this product will be used in housing and other construction work.

Foundation work has already commenced on the new blooming, bar and billet mill. This mill will replace the existing blooming mill and a combination rail mill.

Test borings have been made for the bessemer plant, but construction has not yet started. When completed, this mill will increase the steel output and along with other improvements the eventual pipe making capacity at Lorain.

The new quarter mile long warehouse is now in operation and many carloads of mixed pipe are leaving its doors daily. Entirely new in design, the building will allow efficient and systematic stocking of standard pipe and tubing and easy loading of mixed cars of widely varying classes and sizes of pipe.

Employment at the Lorain plant, largest pipe mill in the world, varies between 11,000 and 12,000 men and women.

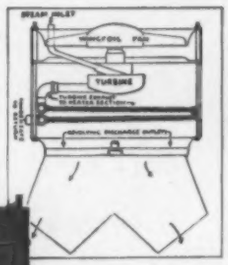
This open side 60 in. shear will take material up to 24 in. It is constructed so that cut material may be dropped directly into a railroad car.

UNITED BUILDS SHEAR TO CUT 24 IN. SCRAP

▲ A giant, new open side 60-in. shear was designed and built by United Engineering and Foundry Company for cutting ship scrap into charging box sizes. It has an extremely large shear opening which will take material up to 24 in.; and is constructed so that the cut material may be dropped directly into a railroad car. It is 19 ft 1 in. high × 16 ft wide and is driven by a 100 hp motor through a stop motion clutch. Total weight is 217,000 lb. Shipping weight including blocking, 218,400 lb.

Because of its unusual size it was necessary to ship the shear on its

THE STEAM THAT DRIVES THE FAN HEATS THE AIR



Cross-section of heater and discharge outlets, showing fan, turbine, heating section and revolving discharge.

The Wing Turbine Driven Revolving Unit Heater is a new type of unit heater combining the advantage of turbine drive for the fan with the use of the turbine exhaust to furnish the steam for the heating section. The steam condensed in heating the air has thus already been used to operate the fan turbine.

WING TURBINE REVOLVING HEATER

Wing

REVOLVING

UNIT HEATERS

. . . eliminates the need for electric motor and electric power. There is no back pressure on the turbine, hence no leaks and no need for power-absorbing troublesome packing. Write for complete details —

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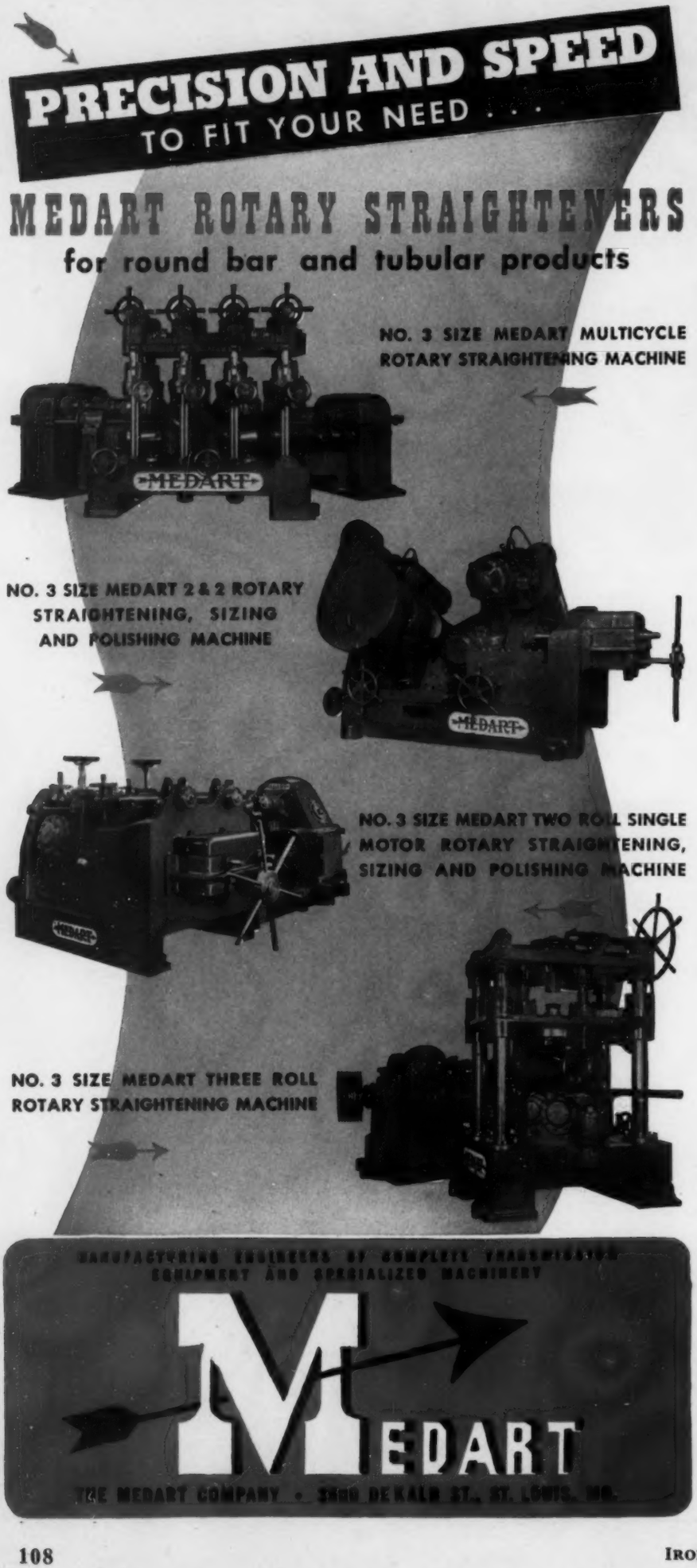
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TO FIT YOUR NEED . . .
MEDART ROTARY STRAIGHTENERS
for round bar and tubular products
NO. 3 SIZE MEDART MULTICYCLE ROTARY STRAIGHTENING MACHINE
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MEDART
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side and remove a portion of the car bottom to accommodate the drive head. The railroad detoured the shipment to avoid all tunnels and restricted its movement to daytime travel at restricted speed between 4 and 10 miles an hour. The shear drive shaft and gear assemblage was shipped in a separate car.

STEEL & WIRE FIRM BUYS TWO CRANE CAB COOLERS

▲ American Steel and Wire Company, Cleveland, Ohio, is installing two Dravo crane cab coolers on crane cabs operating over annealing furnaces at the firm's Cuyahoga works. Crane cab coolers establishes comfortable working conditions for crane operators by controlling temperatures in the cab and filtering fumes and gases from air entering the cab.

U. S. STEEL EXPANDS CAPACITY IN CHICAGO

▲ United States Steel has appropriated over 50 million dollars in 1947 for plant improvements and for expansion and modernization of its facilities in the Chicago district, bringing the total expended for these purposes in this area since 1941 to nearly 300 million dollars.

Typical items included in this program are the enlargement of several blast furnaces; modernization of harbors and docks; enlargement and modernization of coking plants; improvement of power facilities; improvement and enlargement of sheet and tin plate mills, and modernization of structural fabricating facilities. Water supply, sewage disposal, sanitation and hygiene developments also have required major expenditures.

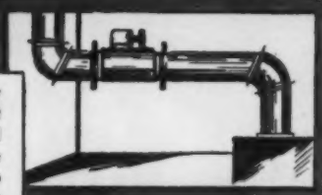
United States Steel subsidiaries in the Chicago area are American Bridge Company, American Steel and Wire Company and its Cyclone Fence division, Carnegie-Illinois Steel Corporation, Gerrard Steel Strapping Company, National Tube Company, United States Steel Products Company, United States Steel Supply Company and Universal Atlas Cement Company. Their combined monthly payroll is approximately $16,000,000.

These Chicago area plants make up the largest integrated steel unit in the world, using 19,000,000 tons

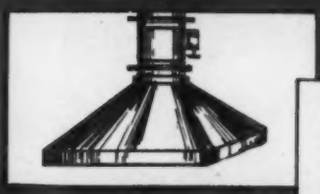
(*Please turn to page 113*)

AXIAL FLOW FANS-

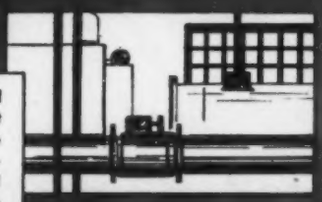
WHEN TO USE THEM TO ADVANTAGE



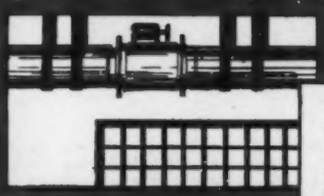
WHEN the fan fits naturally into the middle of a straight duct system. Here the Axial Flow type is installed with the least disturbance, and to special advantage when the system is overhead.



WHEN a vertical air removing system is used — as in exhausting from a hood or paint spray booth—the Axial Flow Fan can be set directly over the opening with the duct straight up.



WHEN space is limited Axial Flow Fans take all straight connections (which take up the least room) — while Centrifugal Fans require curved connections, which take up valuable room.



WHEN you have a fan-supporting problem, but still need high air volume. Axial Flows are lighter and smaller than Centrifugals—are more easily supported from ceilings or walls.

Axial Flow Fans fit very well into many industrial and commercial applications where space-saving is important, where an expensive platform can be eliminated, and where straight-line air flow is desirable.

In other cases, they offer no real advantages over Centrifugals and for that reason, Buffalo offers both types.

Bulletin 3533-B gives full details and ratings on Axial Flow Fans. Bulletin 3339 gives the same information on Type LL Centrifugal Fans. Write for copies of both for your files.

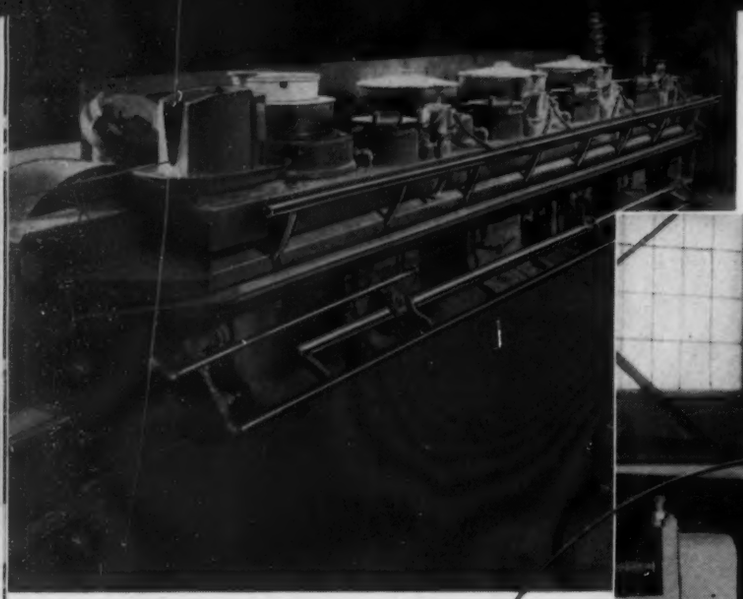
BUFFALO FORGE COMPANY

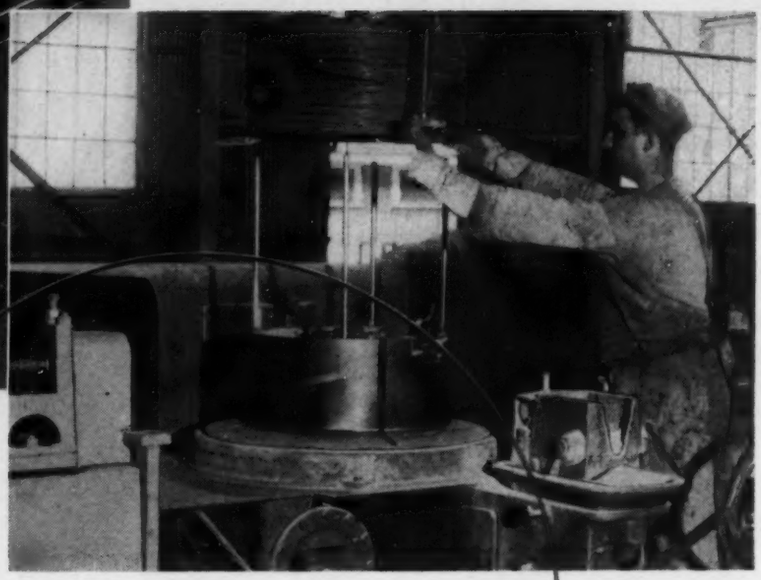
173 MORTIMER STREET · BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo" AXIAL FLOW FANS

CENTRIFUGAL FANS





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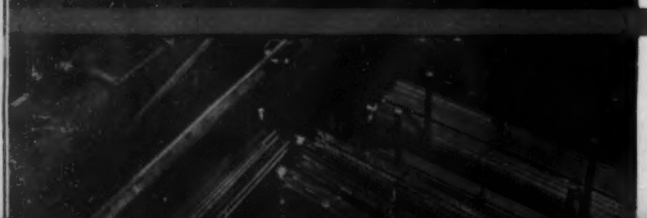

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SPEEDS CHIPPING . . . . .
One Billeteer does the work of 10 manual chippers . . . and does it better. No let-up in its speedy, steady output.

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CUTS LABOR COSTS . . . . .
One large user found Billeteer conditioning cost 56% less per ton than hand chipping . . . 39% less than scarfing.

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BOOSTS WORKER EFFICIENCY . .
The 45 ton weight of the Billeteer takes the punishment of chipping . . . spares the operator from jitters and fatigue common to manual chipping.

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INCREASES SAFETY . . . . . .
490,000 man hours of Billeteer operation and only one disabling accident . . . that's the safety record of Billeteers in one leading steel plant.

5

CHIPS 100% RECOVERABLE . .
Every chip comes clean . . . can be classified according to analysis. Many plants find each Billeteer saves up to 1½ tons of chip scrap a day.

6

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7

REDUCES BILLET INVENTORY . .
Since otherwise "unsalvageable" billets can be saved it is possible to reduce the required inventory of billets and ingots to a minimum.

8

SPEEDS CRITICAL DELIVERIES .
By permitting reclamation of bad individual billets and even bad heats, it facilitates maintenance of delivery schedules and reduces pick-up items at the melt shop.

PUT THESE BILLETEER BENEFITS to work for you.

Write today for complete information.

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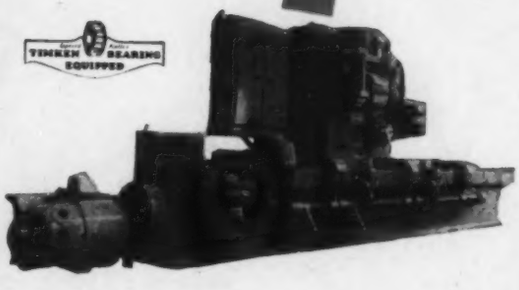

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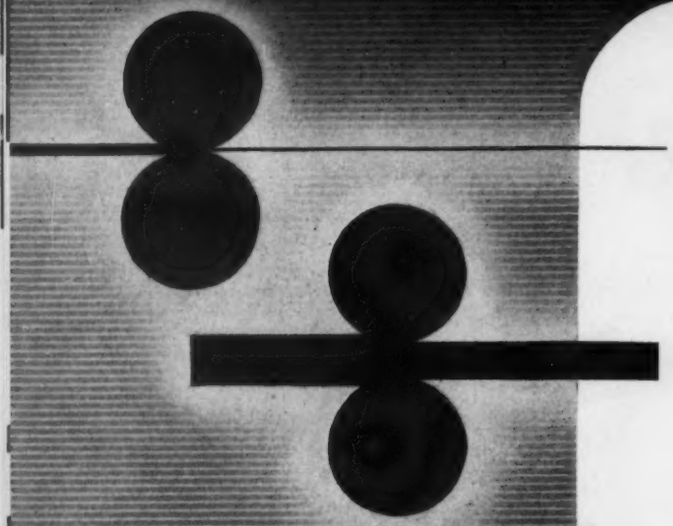

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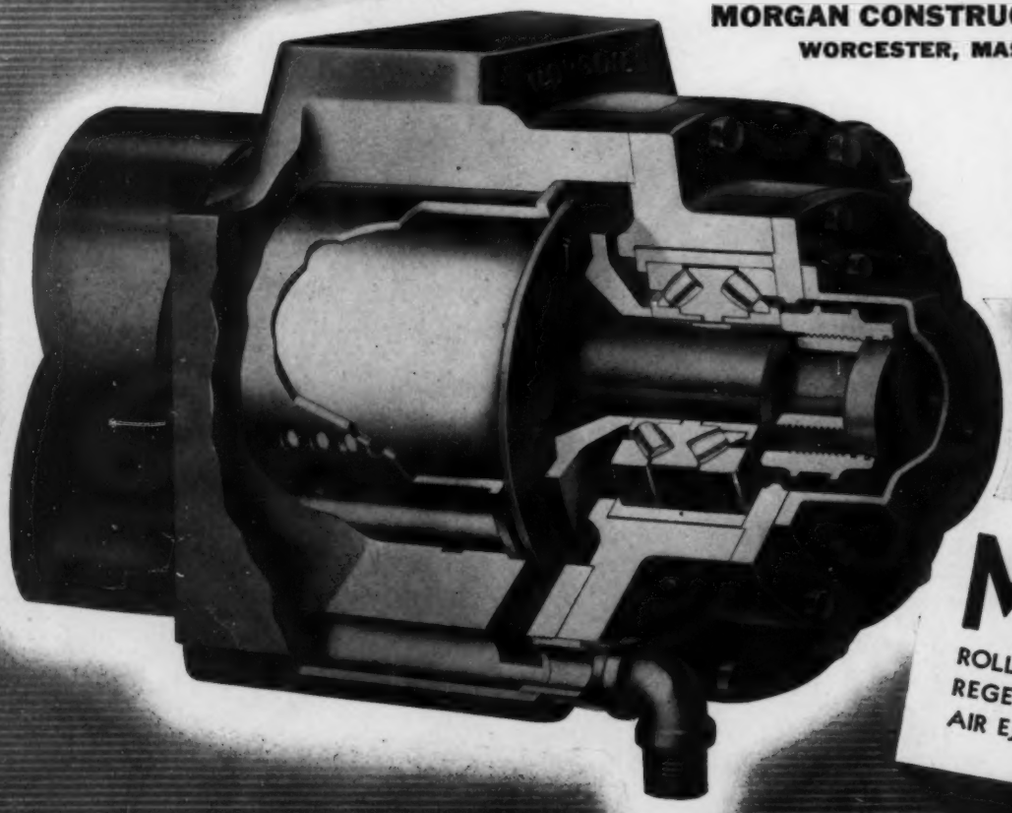

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WORCESTER
ROLLING MILLS • WIRE MILLS
REGENERATIVE FURNACE CONTROL
AIR EJECTORS • GAS PRODUCERS

(*Continued from page 108*)

of iron ore and coal annually and producing 600 carloads of steel products each day.

To maintain pig iron production at its Gary and South Chicago works, Carnegie-Illinois is rebuilding and enlarging four blast furnaces, two at Gary and two at South Chicago, each from a capacity of 800 tons to 1500 tons per day, making them among the largest in the world. Carnegie-Illinois also is proceeding to install two new ore bridges at Gary and replace ore and coke pockets in connection with blast furnaces Nos. 5 to 10 at South Chicago. Foundations for one of the trestles in connection with the South Chicago construction have been laid and steelwork for the trestle is now being fabricated. At both South Chicago and Gary, large-scale improvements of power plants soon will be under way, involving installation of new turboblowers and boilers.

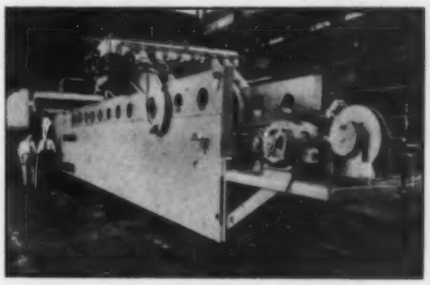
American Steel and Wire Company, which has its principal Chicago area operations at Waukegan and Joliet, has completely rebuilt its Joliet works since 1940 increasing the productive capacity of this merchant products wire mill. At its Waukegan works, the company has made extensive improvements in the past few years to increase that plant's output of manufacturer's wire products. Also at Waukegan, American Steel and Wire has placed orders for new facilities for the production of stainless steel wire which will make that plant one of the major stainless steel round wire producers in the country. It is hoped these facilities will be in operation in the spring of 1948. The Waukegan plant intends, in the very near future, to extend and improve its spring mill producing facilities, part of which are devoted to the finishing of valve spring wire, an important product made at the Waukegan plant, and which, prior to World War II, was imported from Sweden.

Another U. S. Steel subsidiary carrying on an extensive improvement program is American Bridge Company, which has almost completed the modernization of its Gary plant, making possible more efficient fabrication of structural steel for railroads, bridges, highways and buildings.

Gary also is the site of an extensive program of installing improved facilities inaugurated last year by National Tube Company, and scheduled for completion in 1948. This includes a seamless mill for the production of small-sized pipe, as well as electric welding equipment to produce tubing up to 5-inch outside diameter.

HYDROPRESS BUILDS LARGEST LEVELER

▲ A stretcher-leveler of special design, believed to be the largest ever made, was built by Hydropress, Inc. The machine which is shown in the picture after shop erection, is of the self-contained oil hydraulic type, has a capacity of 825 tons and is adapted to accommodate plates or sheets up to 100 in. wide. The maximum length of the plates is 33 ft and the minimum length 7 ft. Two gripheads are provided of which one is actuated by the hydraulic stretching cylinder, while the position of the other one is adjustable to compensate for the varying length of the plates. Operation of the machine is effected by remote control from the operating panel. Pressure adjustment over a wide range is provided for handling thinner and narrower plates at the accurate required pressure.



This unit is believed to be the world's largest stretcher-leveler.

ALLIS-CHALMERS INSTALLS ANNEALING EQUIPMENT

▲ New annealing process equipment, including an electrically heated, 180-kw, 208-volt, three-phase high temperature elevator furnace has been installed at the main works of the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, for tempering punchings of magnetic material in a hydrogen or nitrogen

(*Please turn to page 115*)

With the New
URQUHART COMBUSTION PROCESS
"just a twist of the wrist"...

Converts from Oil to Gas or Gas to Oil

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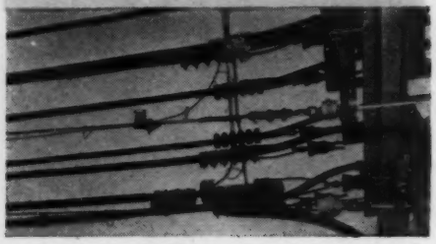
Subsidiary of FORT PITT BRIDGE WORKS
KEYSTONE HOTEL BLDG., PGH., PA.

INSTALLED IN 1905, this 250-volt D.C. feeder is giving good service. Conductors are 1,590,000 c.m. aluminum T.B.W.P. cables.

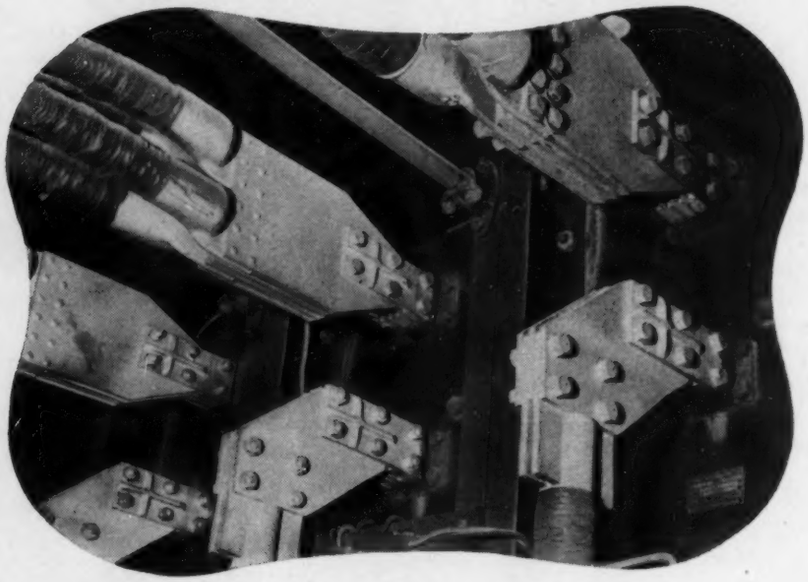
BOLTED DEAD-ENDS on 1,590,000 c.m. aluminum T.B.W.P. cable (Bottom conductors) installed in 1913 in a machine shop for 250-volt feeder.

YARD LINE installed in 1915. Bolted run and soldered tap, aluminum T connectors shown alongside parallel groove clamps installed for later temporary taps.

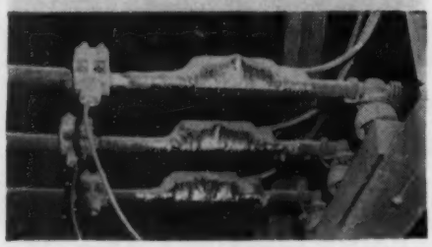


1,590,000 C.M. aluminum T.B.W.P. cable 2200-volt feeder along river. Original aluminum T connectors, bolted run and soldered tap, installed in 1915.

450-VOLT D.C. Line carrying 1390 amperes per cable in a Rotary Converter Station. Four 1,590,000 c.m. aluminum T.B.W.P. cable connections to switchboard using soldered copper lugs. 1700 lugs installed in 1916. Less than 5% of lugs have been resoldered.



220-VOLT 3-phase A.C. Feeders in use since 1915 in a carbon plant. Original aluminum T connectors from 795,000 c.m. aluminum T.B.W.P. cable to No. 8 copper tap. Parallel groove tap under tape made at later date.

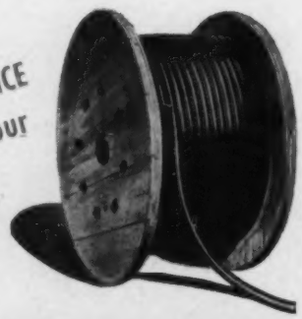


No Problems *of conductivity*
No Problems *of joints and terminals*
No Problems *of conduit layouts*
No Problems *of availability*

Proof of Performance!

Typical Alcoa E. C.* Aluminum Conductors on the job for more than 30 years *and still in service*

The BIG DIFFERENCE is in your COSTS



Alcoa E. C. Aluminum, "the conductor of the present and future", has a *past*, too! The six installations of Alcoa E. C. Aluminum Cable shown here, all in daily service for more than three decades, are proof that you can *count on* aluminum.

On your next installation or replacement job, *figure it in aluminum*—for lower over-all job costs, for better over-all service.

Light, dependable, conductive Alcoa E. C. Aluminum Wire and Cable is now available from leading wire manufacturers who draw, strand and insulate it and sell it under their own trademarks. Your cable supplier can tell you about it. Or write ALUMINUM COMPANY OF AMERICA, 2128 Gulf Building, Pittsburgh 19, Pennsylvania.

* E.C.: Electrical Conductor Aluminum

Insulated and sold by leading wire manufacturers

ALCOA EC ALUMINUM

FOR ELECTRIC WIRE AND CABLE

(*Continued from page 113*)

The new electrically heated furnace is shown ready to receive six tons of steel.

atmosphere up to a maximum temperature of 2150 F.

Capacity of the new furnace for all grades of oriented steel is estimated at 650 tons annually. Loading dimensions are 11 ft by 8 in. long by 40 in. wide and 20 in. high. An average load consists of about 12,000 lb of steel punchings. Two loading cars are provided, each having a driving motor so that the car can be conveniently run under the furnace for automatic raising into position, or run out from under the furnace.

New atmosphere equipment installed for the production of nitrogen includes a 500 cfh output high ratio type combustion propane gas converter, 500 cfh output carbon dioxide removing equipment, and a dual chamber absorption dryer. For the processing of hydrogen, a copper purifying furnace, a cooler, and a dual chamber absorption dryer have been added.

The new annealing process equipment will result in a lower watt loss per pound over steels previously used with a corresponding reduction in weight, size and copper for transformer products.

SUPERIOR STEEL ORDERS THREE-HIGH ROUGHER

▲ Superior Steel Corporation has placed an order with the Lewis Foundry and Machine division of the Blaw-Knox Company to cover the installation of a new 3-high roughing mill to be used in conjunction with the modernization of their hot mill facilities at Carnegie, Pennsylvania. The program involves an expenditure of approximately $1,500,000.00 and is being executed primarily for the purpose of improving the quality of hot rolled products and increasing the width of clad metals; thus making Superior products available in a greater size range within the strip classification. This new mill is expected to be in operation by January 1, 1949.

TURBOBLOWER INCLUDES INTERNAL COMBUSTION

▲ The North American Manufacturing Company is expanding its regular line of turboblowers to include an internal combustion engine powered unit. It is designed primarily for emergencies caused by power failures. The unit is compact yet the air-cooled engine, v-belt drives and impeller jackshaft are all very accessible for greasing, cleaning, or adjusting.

(*Please turn to page 118*)

PEERLESS

Builds the Pump You Require...in Vertical and Horizontal Types

CAPACITIES: 10 to 220,000 g.p.m.

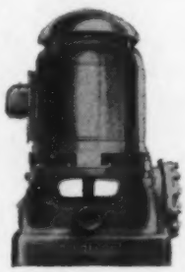
DRIVES: ELECTRIC AND OTHER TYPES

LIFTS: TO 1000 FEET

PEERLESS PUMPS

PEERLESS DEEP WELL VERTICAL TURBINE PUMPS

OIL OR WATER LUBRICATED TYPES



Peerless Moturbo Drive illustrated

General Specifications: *Capacities*, from 15 to 30,000 g.p.m.; *Lifts*, to 1000 feet; *Drives*, electric, gear, belt or combinations. For wells 4" inside diameter and larger. Embodies patented Double-Bearing and Double-Seal Bowl construction.

Peerless Vertical Turbine Pumps complement the extensive Peerless Centrifugal Pump line and are adaptable to the widest pumping conditions. Peerless' vertical type pump line includes turbine pumps, propeller and mixed flow pumps, Hi-Lift pumps and domestic water systems for deep or shallow wells. REQUEST BULLETIN.

PEERLESS TYPE A CENTRIFUGAL PUMP

General Specifications: *Capacities*, from 50 to 70,000 g.p.m.; *Heads*, 15 to 300 feet; *Sizes*, 2" to 42" discharge; *Drives*, electric and other types from 1 to 1000 h.p.; *Type*, single stage, double suction, split-case, ball bearing. REQUEST DESCRIPTIVE BULLETIN.

PLAN WITH PEERLESS

For all your pumping requirements, plan with Peerless. Peerless' comprehensive line of pumps includes Underwriters' approved Fire Pumps for plant fire protection, boiler feed and pipe line pumps and scores of vertical and horizontal types offering capacities from 10 to 220,000 g.p.m.

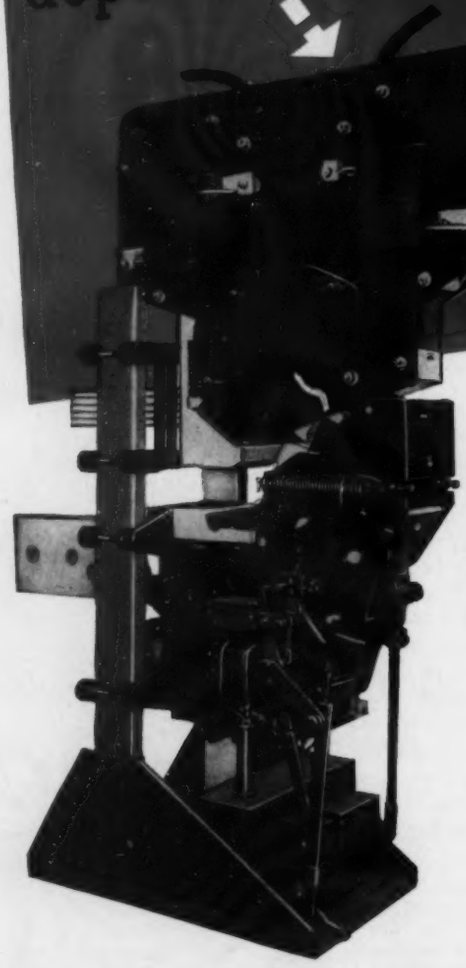
PEERLESS PUMP DIVISION

FOOD MACHINERY CORPORATION

Factories: Indianapolis, Ind. • Quincy, Ill. • Los Angeles 31, California

District Offices: Chicago 40, 4554 North Broadway; Philadelphia: Suburban Square, Ardmore, Pennsylvania; Atlanta: Rutland Bldg., Decatur Georgia; Dallas 1, Texas; Fresno, California; Los Angeles 31, California.

Guard your production with this dependable protection



Type MT single pole, electrically operated, Automatic Reclosing Circuit Breaker. 250 and 750 Volts — D-C.

Interrupting Capacity is 150,000 Amp. in ratings 2000 and 4000 Amp.; and 250,000 Amp. in ratings 6000 and 12,000 Amp.

ELECTRICAL disturbances in your power distribution system hit you where it hurts most—right in the heart of your production.

Protect your essential production equipment from the hazards of electrical disturbances with the I-T-E MT (Mill Type) Automatic Reclosing Circuit Breaker. The MT is a unit of dependable, full-time protection; engineered and built by I-T-E—*specialists* in *quality* Switchgear.

Especially designed for quick interruption of extremely heavy direct-currents, the MT breaks a circuit in about 1¾ cycles (60 cycle basis) at 25% to 100% of interrupting capacity. Minor disturbances are cleared—through quick opening and automatic reclosing—with virtually no interruption of service.

It is electrically and mechanically trip-free on overcurrent, and trips immediately when closed on a fault. All tripping devices are direct-acting and instantaneous. The main contacts are solid copper blocks with silver alloy inserts for protection from oxidation and overheating. Secondary contacts guard the main contacts from arcing damage. Arcs are quickly and safely extinguished by the I-T-E designed magnetic blow-out coil and arc chute.

Normally built in two styles—for either panel mounting or pedestal mounting, the MT has a sturdy frame of hot-rolled steel, formed and welded into a rugged, protective support unit. Pantograph drawout and truck mountings can also be furnished if desired.

For complete details on the I-T-E Type MT Automatic Reclosing Circuit Breaker, send for illustrated catalog 2201. *Ask the I-T-E representative in your locality for information on applying the MT—and other I-T-E protective equipment—to your electrical distribution system. His services are available with no obligation.*

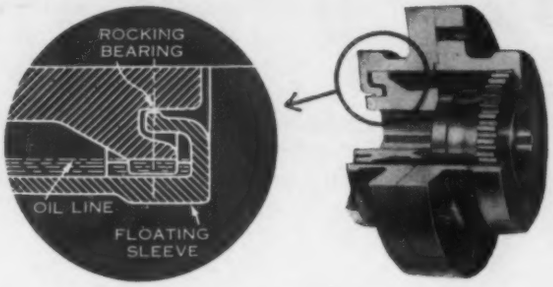
I-T-E

MILL TYPE SWITCHGEAR

The Leader In Technical Excellence

I-T-E CIRCUIT BREAKER CO., 19TH & HAMILTON STS., PHILADELPHIA 30, PA.—31 OFFICES IN UNITED STATES AND CANADA

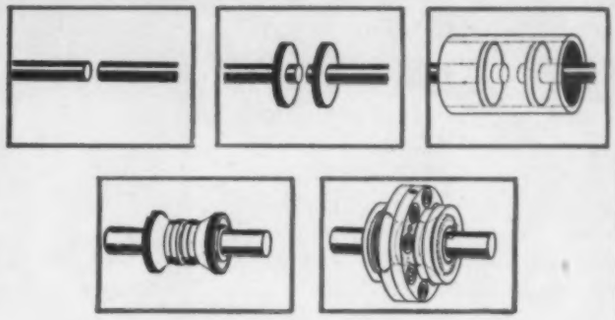
SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS • HIGH SPEED CIRCUIT BREAKERS



HERE'S HOW FAST'S Eliminates Perishable Parts!

No matter which type of Fast's Coupling you use, you can be sure of this . . . it will be all-steel throughout . . . without a single perishable part! As an example, the exclusive "rocking bearing," shown above, provides a positive metal-to-metal seal to protect the load-carrying oil against moisture, dust and grit. No perishable packing rings are used. There's nothing to wear, nothing to fail.

1

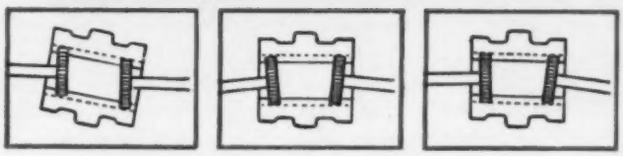


HERE'S HOW FAST'S Are Constructed— Simple as A-B-C!

See the simple development of Fast's self-aligning Couplings. A splined hub on each shaft end. A sleeve with internal splines to mesh. Oil in the sleeve, kept between the splines by centrifugal force, carries the load between the splines.

2

These Facts About the ORIGINAL Gear-Type Coupling *Can Save You Costly Coupling Shutdowns*

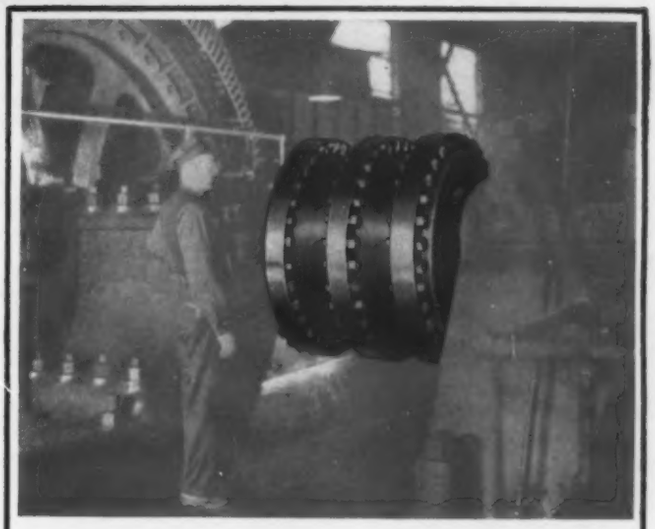


HERE'S HOW FAST'S COUPLINGS Compensate for Misalignment!

The floating sleeve takes a neutral position. All forms of misalignment are compensated for between the lubricated faces of the splines, equally divided between the driving and driven members. The entire assembly revolves as one unit.

3

WE HAVE *a complete line of couplings for immediate delivery. Get full details on Fast's Couplings now by writing for our complete catalog. Just drop a line to:* Koppers Co., Inc., Fast's Coupling Dept., 311 Scott St., Baltimore 3, Md.



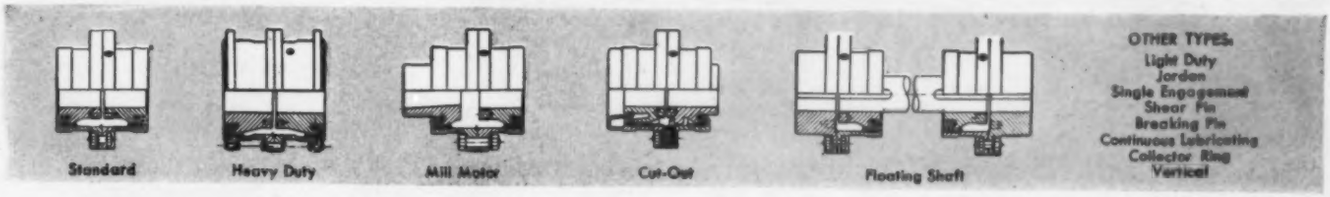
HERE'S HOW FAST'S COUPLINGS ARE USED

This Fast's Coupling, installed in 1922 and still transmitting power from a 3000 H.P. motor to a billet mill in the Midland Works of Crucible Steel Company of America, is a good example of the way Fast's Couplings give uninterrupted power transmission. When you buy Fast's Couplings, you buy many years of top engineering experience, Koppers' high standard of workmanship and unexcelled coupling service. Result: longer machine life, lower upkeep costs, minimum shutdown losses.

4

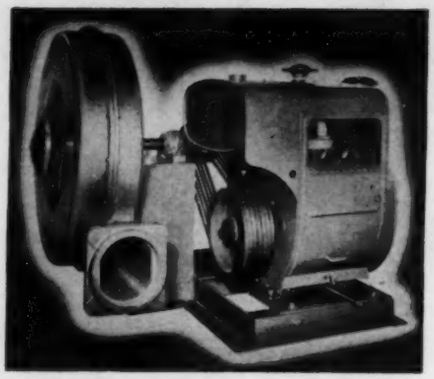
KOPPERS

FAST'S *self-aligning* COUPLINGS



(*Continued from page 115*)

For combustion systems using oil burners an oil pump may be had with the unit which is built in as an integral part. The entire combustion system is thus self-contained. The sturdy welded steel base is designed to permit belt tension adjustments without fear of misalignment. A governor on the engine assures a steady speed for the turboblower and the oil pump. A constant air and oil pressure results. As a stand-by unit the engine driven turboblower is on the job to prevent the loss of thousands of dollars which could result from lack of necessary combustion air in furnace operations.



The unit lends itself well to applications requiring portability, such as scove kilns in brick yards and portable aggregate dryers used in highway construction.

YOU GET BETTER STEEL by this BETTER Modern Method

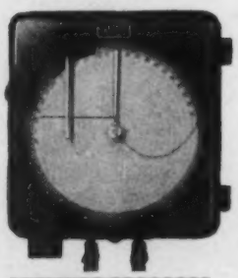
FURNACE PRESSURE CONTROLLER

Equipped with external manual adjustment for automatically operating stack damper to hold pressure constant.

These Hays Instruments may be used in Combination or Individually.

PRESSURE INDICATOR

An easy-to-read measurement of furnace pressure. Usually connected at the furnace roof.



PRESSURE RECORDER

A 24-hour record of furnace pressure. Shows timing of reversals and each change of pressure made by the operator during the heat.

IN up-to-the-minute open hearth plants you will find an increasing reliance on Hays Pressure Control.

Automatically this simple system regulates furnace conditions --relieves operators of many time-consuming details, gives them more time for more important duties. And Hays instrumentation can be complete or partial.

Here for a fact is "smart business." Better get the facts—write for them, or have a Hays engineer tell you about this better modern method. Representation in all principal cities of the United States and Canada.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

J & L ADDS TO CAPACITY AT OTIS STEEL WORKS

▲ In line with their general program of postwar reconversion and expansion the Jones and Laughlin Steel Corporation is adding to the capacity of its Otis works. Included in this program is a new open hearth furnace designed to furnish additional steel making capacity for their strip mills. This furnace is of the basic open hearth type, with a rated capacity of 175 net tons.

The first basic open hearth furnace in the United States was installed at the Otis works in 1886 in a part of the works now dismantled. Today, over 90 per cent of the steel produced in the U. S. A. is made by this process. Jones and Laughlin's new open hearth furnace is being engineered and constructed by Loftus Engineering Corporation and will embody the latest features of open hearth design.

CARDOX TO REPRESENT CONTINENTAL GENERATORS

▲ The appointment of Cardox Corporation, of Chicago, as exclusive sales representatives for Continental inert gas generators has been announced by Continental Industrial Engineers, Inc.

The appointment in no way affects Cardox' continuing activities in the engineering, manufacture and sale of fire extinguishing systems and mobile apparatus, using low pressure carbon dioxide, the manufacture and distribution of liquid carbon dioxide or other activities of Cardox in the coal mining industry.

Continental will likewise continue to design, make and sell special machines, industrial furnaces and kilns

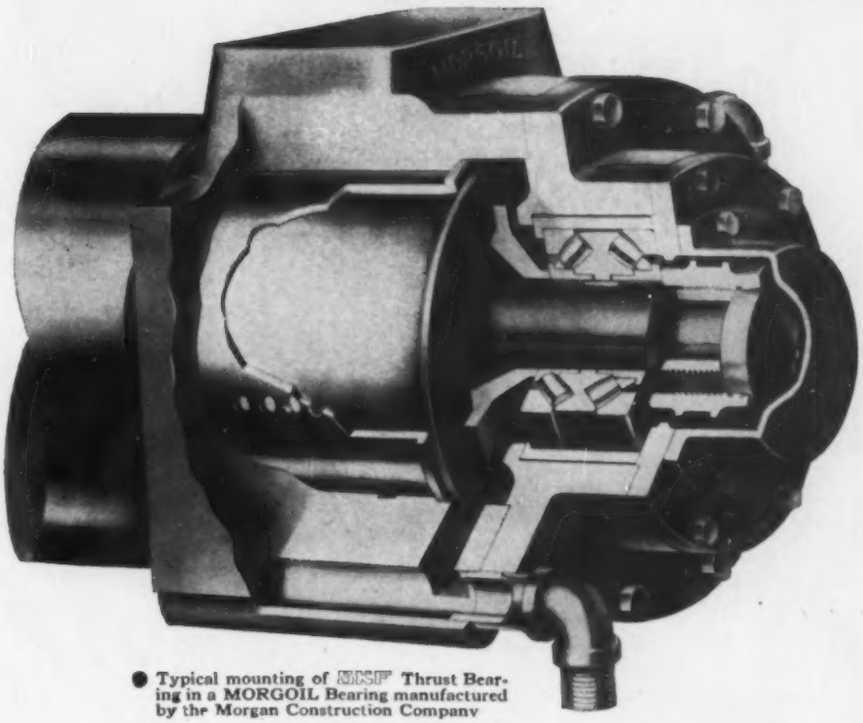
(*Please turn to page 120*)

PREFERRED

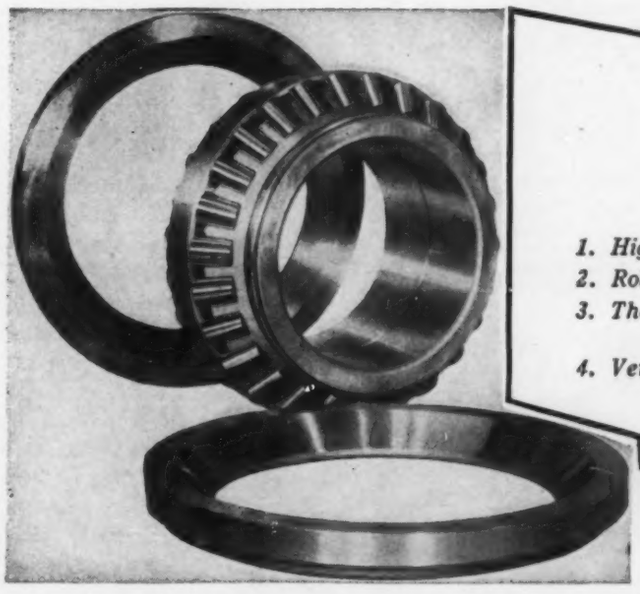
for Back-up THRUST

Four years ago SKF, the pioneer in the application of spherical roller bearings to rolling mills, developed the double directional adaptation of its spherical roller bearing for use as the thrust unit in MORGOIL Bearings manufactured by the Morgan Construction Company. First installed on the back-up rolls of a modern 4-High 80" hot strip mill, its ability to carry heavy thrust loads has made it the logical choice for the newest hot strip mills and high speed cold mills now being installed. 6322

SKF INDUSTRIES, INC., Phila. 32, Pa.



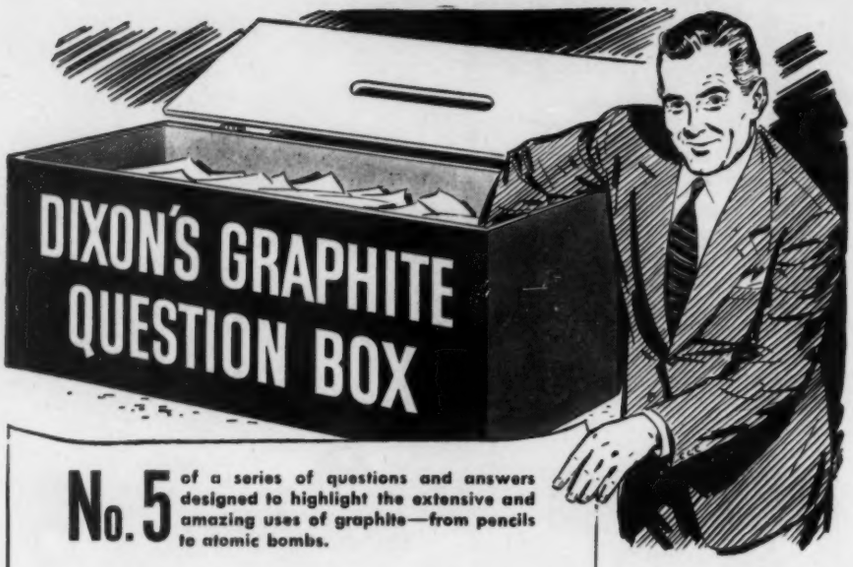
● Typical mounting of SKF Thrust Bearing in a MORGOIL Bearing manufactured by the Morgan Construction Company



SKF

SPHERICAL ROLLER THRUST BEARINGS

1. *High thrust capacity.*
2. *Rolling alignment.*
3. *The ability to run at sustained high speeds.*
4. *Very low friction torque.*



No. 5 of a series of questions and answers designed to highlight the extensive and amazing uses of graphite—from pencils to atomic bombs.

GRAPHITE IN THE ROLLING MILL

QUES. Why is graphite used in boiler water?

ANS. To prevent scale from burning fast to the shell and tubes. Boiler cleaning is made fast and easy, reducing cleaning time, labor cost and fatigue.

QUES. Is graphite effective in lubricating, retarding wear and prolonging the service life of dies and punches?

ANS. Definitely yes. Graphite, a "solid" lubricant, is not readily forced or squeezed out between surfaces under pressure as with oil, grease or fluid lubricants. It often serves best when all other lubricants completely or partially fail.

QUES. Does graphite speed up assembly of stamped, forged, machined or cast parts?

ANS. Reported savings in labor, time and operator fatigue are almost incredible. Many manufacturers barrel-tumble parts, a low-cost automatic method of coating them with graphite.

QUES. Is graphite the best lubricant for chains, bearings and other parts of industrial ovens, lehrs and kilns that operate at high temperatures?

ANS. Graphite is the only lubricant that proves wholly and lastingly adequate in such service.

QUES. How are graphite products used in welding and brazing?

ANS. As electrodes, and as "stoppers" or "fillers" to plug openings and keep work areas and work free from excess flux and spelter.

A few of thousands of widely used products containing Dixon's Graphites. Those starred are Dixon's products, many of them sold by supply houses everywhere.

★ Lathe Center Lubricant

★ Graphitoleo

★ Cup Grease No. 3

Now may we receive *your questions* on how graphite can help *you?*

DIXON'S GRAPHITES

Products of
JOSEPH DIXON CRUCIBLE COMPANY
Jersey City 3, N. J. Div. 18-Q-11

LOOK FOR No. 6
in this series. We will gladly send you reprints of any you may miss

(*Continued from page 118*)

and to engineer process lines and complete industrial plants.

The Continental inert gas generator produces inert gas from the reaction of fuel gas and oxygen under controlled conditions of combustion. The gas generated is then scrubbed and purified. Its components can be varied according to the use to which they are to be put. Often it consists substantially of pure nitrogen and carbon dioxide, in a ratio of about 9 to 1. It is compressed and stored in tanks of any required size, from which it may be continuously drawn as needed. The generator is entirely automatic in operation, with the quantity of gas produced governed by demand. Special control devices assure uniform composition at all times. The units have capacities ranging from 1500 cu ft to 10,000 or more cu ft per hour. One thousand cu ft of 1000 Btu fuel gas produces about 9000 cu ft of inert gas.

REPUBLIC WINS HONORS IN SAFETY CONTEST

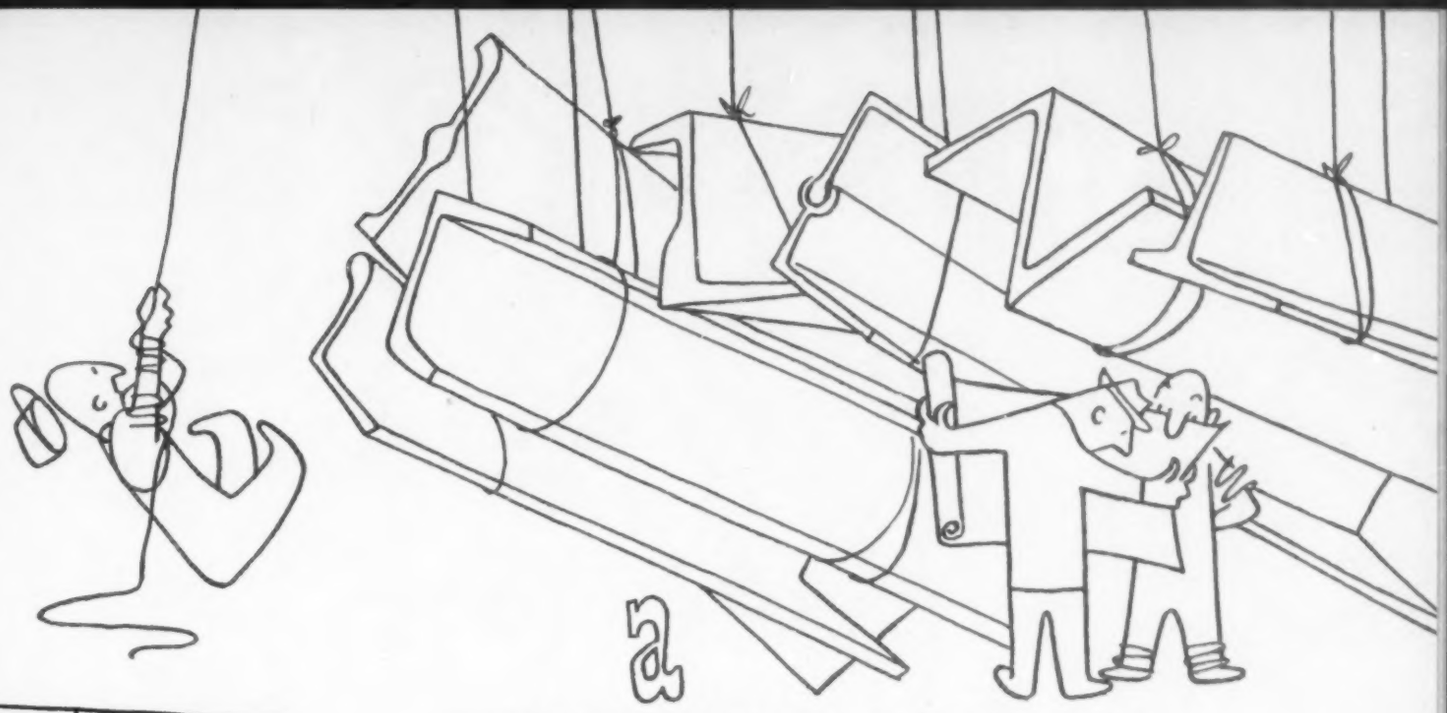
▲ Top honors in safety were won by eleven plants of Republic Steel Corporation, according to a National Safety Council announcement.

Among the 611 industrial plants in the United States competing in the 1946-47 Metals Section Safety Contest, the Republic plants took 9 first and 2 second places. In addition, 11 other Republic plants have qualified for Reduction Awards. These awards are given to plants which have improved their safety performances and which have an accident frequency rate lower than the average of their group.

MOTORLESS HEATER FOR INDUSTRIAL USE

▲ A welcome development in view of the electric motor situation is the introduction of a turbine revolving unit heater by L. J. Wing Manufacturing Company. In this, the fan is driven by a remarkably compact all-steel steam turbine. The turbine exhaust passes into the heater section where it is used to heat the air which the turbine-driven fan then delivers through the revolving discharge out-

(*Please turn to page 123*)

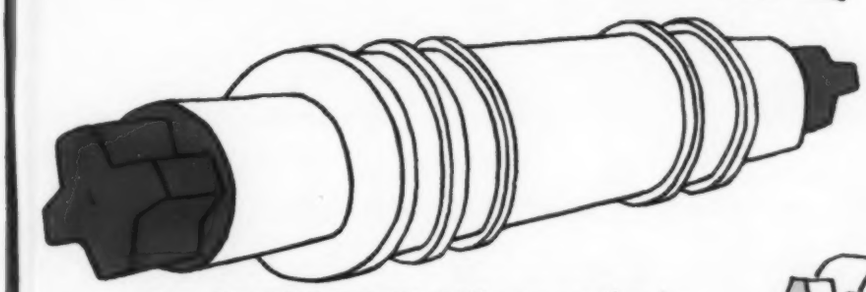


a

INGENIOUS STRUCTURAL SHAPES, which emphasize the peculiarly American genius in structural engineering and construction techniques, challenge the production talents of mill operators and the skill of roll designers.

b

BLOOMING MILLS, rolling endless tons of ingots, demand the ultimate skill of the mill operator—the practical knowledge of rolls, rolling conditions, and mill production standards which assure perfection in the final output of Z-Bars, Bulb Angles, I-Beams, Channels, Tees, and the myriad other shapes.



MACK-HEMP CRAFTSMEN and mill-wise M-H engineers continue to combine their skills to supplement your knowledge in the design, metallurgy and manufacture of Red Wabbler Rolls—the proper rolls for your production rolling operations.

d

c

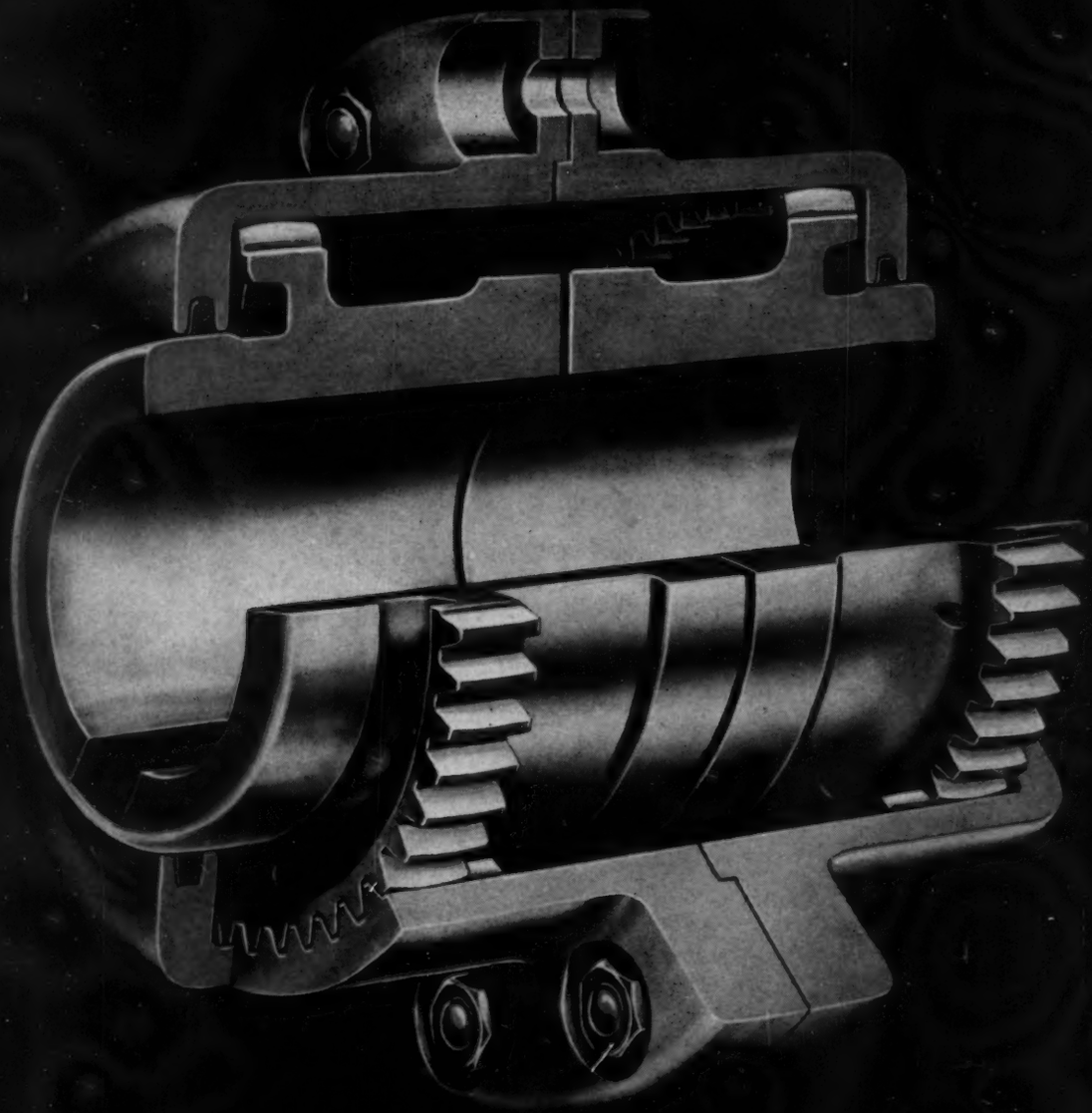
RED WABBLER ROLLS fulfill your exacting demands because your own blooming-mill know-how—the accumulated skill of your years of rolling mill experience—guides Mack-Hemp engineers in the development of rolls which establish production records and set the standards for long roll life.

MACKINTOSH-HEMPHILL CO.

PITTSBURGH AND MIDLAND, PA.

Makers of the rolls with the red wabblers

POOLE



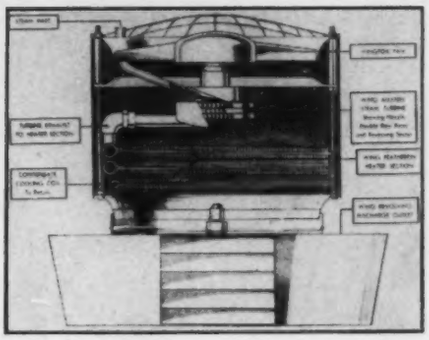
A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

(*Continued from page 120*)



This new heater is a welcome development in view of the shortage of electric motors.

lets to the working level below. Condensate, which is never at a higher temperature than 170 F is returned to the boiler through an open return system. The advantages claimed are elimination of electric motor and electric power, no back pressure, no packing, no traps.

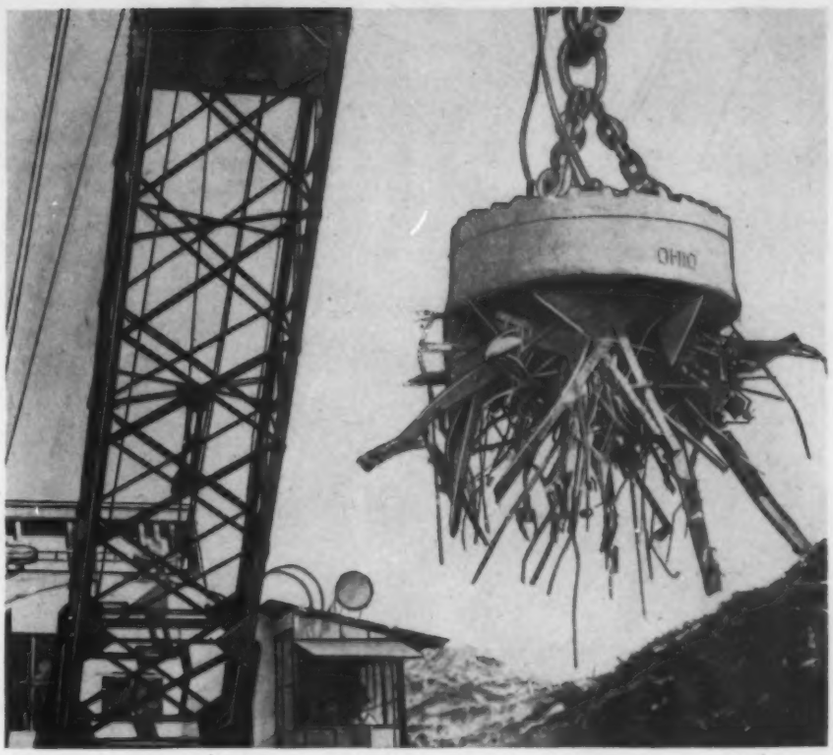
REDESIGN LINE OF FUSE PULLER SWITCHES

▲ Trumbull Electric Manufacturing Company recently announced a new, redesigned line of fuse puller switches, rated at 60 amperes, 125/250 volts, a-c, and measuring 9⅛ in. wide by 14 in. high by 3⅞ in. deep. The streamlined, modernistically designed enclosure presents an attractive appearance, highlighted by the 5 horizontal flutes previously introduced in the new Type D switch design. Four different units are available, two of which contain 4 branch circuits, one main, one range circuit and one water heater connection, and two units containing six branch circuits, one main, one range circuit and one water heater connection. The units are wired either in series or parallel. Solderless lugs are provided for wires ranging from No. 14 to No. 4 for the main, range and water heater connections.

A dead front metal shield, easily removed without tools, covers all live parts. "Off" and "On" positions are clearly indicated on the fuse caps. The switches have non-interchangeable range and main caps.

A total of 30 knockouts are spaced to allow sufficient clearance for grounding bushings and there is ample room inside the box for easy wiring. Two special knockouts for use with a ground cable are provided.

(*Please turn to page 126*)



Hands off!

One lift, one swing, one drop.

Magnetic materials handling moves scrap *directly* to where you want it—in magnet-minutes instead of manhours.

The magnet you invest in determines *how much faster* scrap can be moved. Just as there is a difference in the physical strength of men, there is also a difference in the electrical strength of magnets.

A small 20 inch Ohio Magnet, however, easily lifts more than 200 pounds of high grade scrap. Our larger 65 inch magnet attracts and holds more than 6200 pounds of the same grade of scrap.

Ohio Electric makes 14 different sizes of circular magnets. Fitting the right size magnet to your specific needs doesn't take much time—*but it does take experience.*

Some of our customers frequently say they prefer Ohio Magnets because Ohio chain ears have square holes for chain pins to eliminate friction and prolong life. Others especially like the Ohio Armored Weatherproof Connector with insulated iron shell and bayonet joint. It withstands smashing blows and saves time when making or breaking connections.

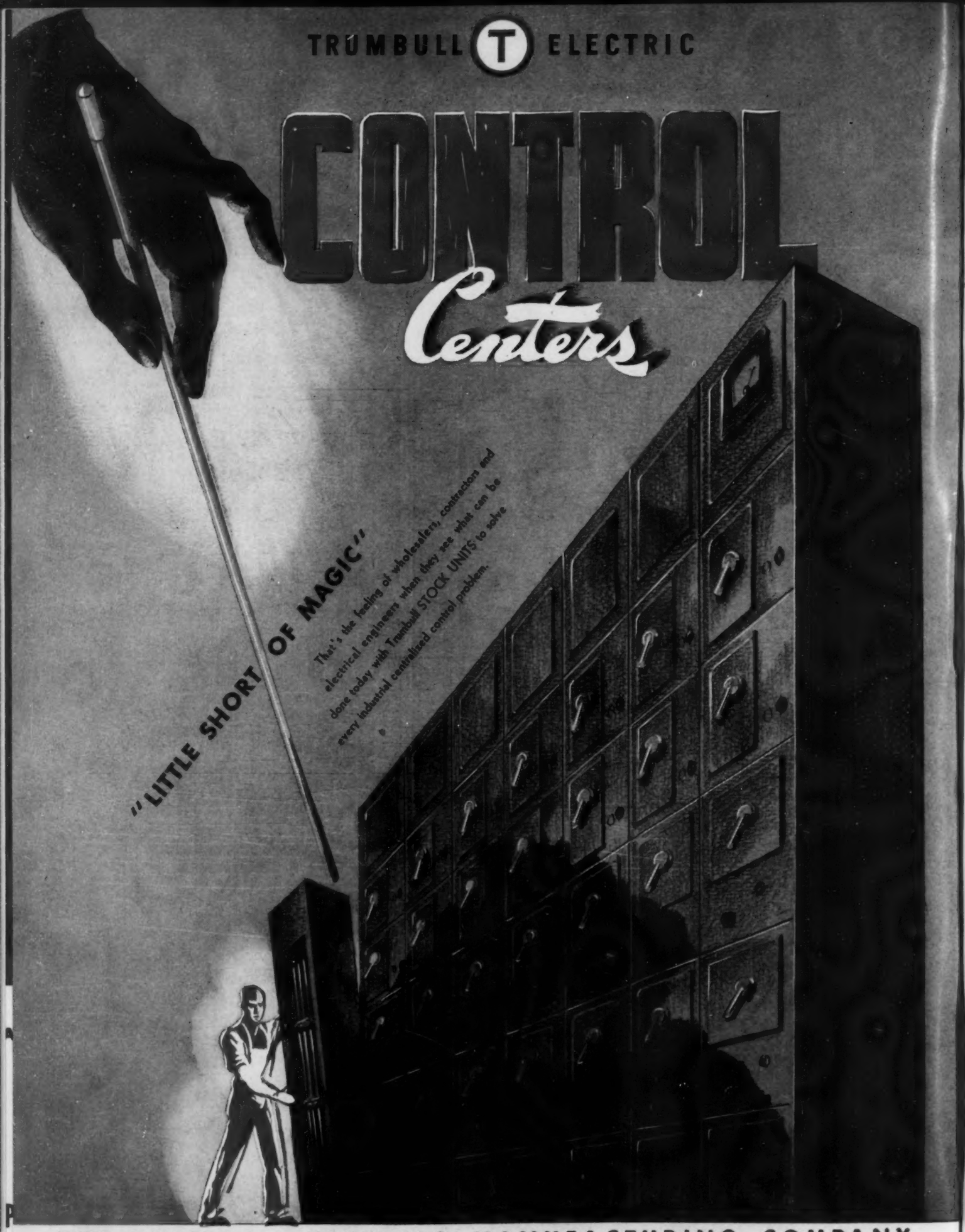
Find out *now* how much you can reduce scrap handling costs. Write to Ohio: *for 25 years a leader in magnetic materials handling.*

Ohio MAGNETS

also a leading name in the small motor field

THE OHIO ELECTRIC MFG. CO.

5907 MAURICE AVE. • CLEVELAND 4, OHIO


TRUMBULL T ELECTRIC
CONTROL
Centers
"LITTLE SHORT OF MAGIC"
That's the feeling of wholesalers, contractors and electrical engineers when they see what can be done today with Trumbull STOCK UNITS to solve every industrial centralized control problem.

THE TRUMBULL ELECTRIC MANUFACTURING COMPANY

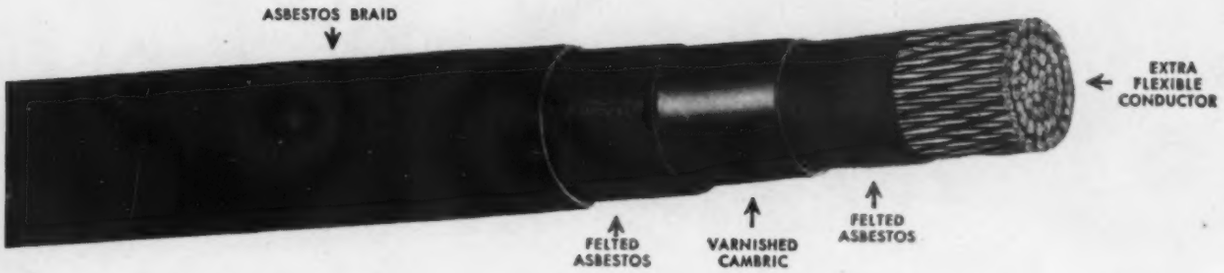
PLAINVILLE, CONNECTICUT

OTHER FACTORIES AT NORWOOD, OHIO • SAN FRANCISCO • SEATTLE • NORTH HOLLYWOOD

SHORT FACTS ABOUT LONG-LIVED CABLE

OKOBESTOS

the cable with the asbestos suit



RESISTS FLAME AND HEAT

Type AVA Okobestos Cable is protected with a heat, flame and moisture-resisting braid made of imperishable asbestos, and is designed for continuous operation at 110°C copper temperature.

RESISTS CORROSION

Its asbestos braid covering is chemically inert. Withstands corrosive fumes, chemicals, oils and solvents.

HAS HIGH DIELECTRIC STRENGTH

A heavy wall of electrically stable Varnished Cambric is inserted between heat-resisting layers of impregnated felted asbestos, and permits operation up to 5000 volts.

IS PERMANENTLY RUGGED

Consisting principally of copper and asbestos — two of the most durable materials known — Okobestos Cable will outlast any job on which it is used. It carries full N.E.C. approval.

YOU CAN GET FURTHER DETAILS

Send for Bulletin OK-2061 covering single and multi-conductor assemblies to The Okonite Company, Passaic, N. J.

6118

OKONITE insulated wires and cables

. . . Silicone-treated

DELTABESTON* CABLES

Wherever high temperatures are a real maintenance problem, economy and safety call for cables that are built to beat-the-heat. That's why more and more hot spots are getting extra wiring protection with the new silicone-treated Deltabeston cables. Asbestos-insulated and covered with a tough glass braid, these new cables are treated throughout with silicone varnish to cut *down time* and maintenance costs at operating temperatures as high as 200 C.

Silicone-treated Deltabeston cables — for 300- and 600-volt service — are built to take moisture and rough handling, too. The tough silicone impregnant keeps moisture out, fights the effects of abrasion.

UNDERWRITERS' APPROVED—These wires are approved for use in the wiring of ovens or other high-temperature equipment, such as furnaces and control apparatus, where the acceptability of the wire for the particular use has been determined by the Underwriters' Laboratories, Inc.

Let us send you specifications and working data. Write to Section Y76-1146, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

*Trade-mark Reg. U. S. Pat. Off.

Beat Motor Heat with Deltabeston Magnet Wire

If you do your own motor winding — or, if you send it to an outside shop, be sure to specify Deltabeston Magnet Wire. It's made in round, square, and rectangular shapes, and is insulated with asbestos or glass for lasting protection and service.

DELTABESTON
Wires and Cables
Built to beat the heat

GENERAL ELECTRIC

(*Continued from page 123*)

The modernized enclosure is highlighted by the five horizontal flutes.

The main and range circuits take N.E.C. cartridge fuses and the branch circuits take standard plug fuses. The device has a grounded neutral. For added safety and convenience, holes are provided in the fuse holder caps for fuse ventilation and for easy inspection of fuse ratings. Additional holes are provided in the caps for testing and in the enclosure for sealing. The entire interior may be removed by loosening one screw.

SERVICE ENTRANCE FITTING IS REVERSIBLE

▲ A new service entrance fitting with reversible head has just been introduced by The Adalet Manufacturing Company. It is so designed that it can be used in the conventional up-

right manner, or the hub may be reversed in such a way that the wires enter and leave the service head in the same plane.

This unique feature is particularly advantageous on the larger sizes of cable.

Simplicity is the keynote of this new Adalet Service head, inasmuch

as the entire assembly is held together with two bolts. The insulating covers are made of reinforced phenolic sheets with smooth, machined holes and edges. This is the same material that has been utilized for many years in the well-known Sali insulating bushings.

Body and head are made of cast aluminum — light, strong and corrosion resistant. Experienced users state that this service entrance fitting is more easily installed than any they have previously used. Available from stock in 2½ in. and 3 in. pipe sizes; 3½ in. and 4 in. pipe sizes will be stock items at an early date.

INTERNATIONAL HARVESTER OPENS RESEARCH PLANT

▲ International Harvester Company on October 21 dedicated its new manufacturing research department in Chicago. The new department is devoted exclusively to manufacturing research, which is thus segregated from all other Harvester operations. Purpose of this was not to divorce manufacturing research from contact with other Harvester units, but to provide a climate in which research projects could be carried forward without distraction.

The entire building contains about 230,000 square feet of floor space, of which 180,000 square feet are used by various sections and laboratories engaged in research.

The administration of the new unit and research activities in the new department are under the direction of M. C. Evans, manager of manufacturing research. Prior to his current assignment he was manager of all the company's tractor manufacturing plants in the United States. Operating head of the new department is J. W. Armour, assistant manager of manufacturing research.

The major subdivisions of the manufacturing research department are:

Administrative section, plant engineering section, mechanical engineering section, materials handling and product protection section, welding section, metallurgical section, protective finishes section (paints, oils, varnishes), inspection methods section, forging section, foundry section, and manufacturing standards section.

Each section has its own supervising head. Each also has a research staff and a group of technicians. Every section has been allotted space in the new department in accordance with its requirements and full-scale research laboratories have been established where necessary.

The manufacturing research department is not a self-sufficient unit in the sense that it has at its disposal all the equipment and facilities necessary to consummate every project it undertakes. It will not maintain facilities at the manufacturing research building where the type, size, and cost of duplicating those facilities within the company would be out of proportion to the research yield.

The objectives of the manufacturing research department are: (1) the investigation of the company manufacturing methods and problems, (2) development of manufacturing standards, and (3) keeping abreast of all developments in the manufacturing world.

The research department also shares other general objectives of the Harvester Company which include: increasing the utility of products, improving quality of products, developing new processes, materials and products, reducing product cost as well as operating and maintenance costs, standardizing methods, collecting technical information, contribut-

(*Please turn to page 144*)

BUT...

It would appear absurd on our streets now — compared with the beautifully designed — high-powered models of the present. In the iron and steel industry — a little

Rodine*

added to the Sulfuric or Muriatic acid bath — marks an equally advanced and revolutionary improvement in pickling technique.

"RODINE" effects more precise control and saves good metal by lessening acid attack and the chances of over-pickling and hydrogen embrittlement. "RODINE" prolongs the life of the bath — saves acid — holds fumes to a minimum — facilitates scale removal. For better pickled surfaces and all around high quality performance — use "RODINE."

* "RODINE" ® for Acid Inhibitors

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING
Granodine *
Duridine *
Alodine *
Lithoform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING
Deoxidine *
Peroline *

PICKLING ACID INHIBITORS
Rodine * ®

AMERICAN CHEMICAL PAINT CO.
AMBLER ACP PENNA.

Personnel News . . . .

R. S. Shoemaker has been made manager of the Cincinnati, Ohio, district for Brooks Oil Company, Cleveland, Ohio. Mr. Shoemaker, formerly general lubrication engineer for American Rolling Mill Company, Middletown, Ohio, started his steel career at the Lorain plant of the National Tube Company about 1903 as electrical construction foreman. In 1905 he was appointed electrical superintendent for the Milliken Brothers, Inc., of New York. He became electrical superintendent at the Monessen plant of the Pittsburgh Steel Company in 1907, and in 1909 was appointed assistant consulting engineer in charge of electric construction at the Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ontario, Canada. During the year 1912 he was employed by the St. Lawrence Bridge Company and the Dominion Bridge Company as electrical superintendent of their plants and in charge of electrical and mechanical maintenance during the erection of the Quebec Bridge at Quebec. Mr. Shoemaker joined the American Rolling Mill Company, Middletown, Ohio, in 1916 as superintendent of maintenance, in 1928 became superintendent of blooming, bar and strip mills, and in 1938 was appointed lubrication engineer.

Mr. Shoemaker is a past president of the Association of Iron and Steel Engineers for the year 1924. He has also served on the AISE board of directors.

Quincy Bent retired as vice president in charge of steel division operations, Bethlehem Steel Company, on November 1, 1947. Mr. Bent will continue as vice president in an advisory and consulting capacity, and as a director of Bethlehem Steel Corporation, until December 31, 1947. As vice president in charge of the steel division operations of Bethlehem he was responsible for steel plant and fabricating works development and activities, including the work of industrial research. Mr. Bent upon graduation from Williams College in 1901 entered the employ of the Pennsylvania Steel Company, was transferred to its Lebanon, Pennsylvania, plant in 1903, became assistant to president of the Maryland Steel Company (a Pennsylvania Steel subsidiary) in 1909, and general manager of its Steelton, Pennsylvania, plant in 1916. Bethlehem Steel acquired the Pennsylvania Steel properties in that year. In 1918 Mr. Bent was made vice president in charge of operations of Bethlehem at the height of the war production activities during World War I; and he continued in that post through Bethlehem's extensive peacetime expansion of its activities and during World War II.

Stuart J. Cort succeeds Quincy Bent as vice president in charge of steel division operations, Bethlehem Steel Company. Mr. Cort was graduated from Lehigh University in 1906. After graduation he obtained early experience in the steel industry at the Duquesne plant of the Carnegie Steel Company and in 1916 went with the Cambria Plant of Midvale Steel and Ordnance Company, Johnstown, Pennsylvania. In 1917 he was appointed superintendent of the Saucon open hearth division of the Bethlehem, Pennsylvania, plant of Bethlehem Steel Company, and in 1922 was made superintendent of the entire Saucon division. In 1928 he was made general manager of the Sparrows Point, Maryland, plant.

John L. Hutton, a graduate of Colorado School of Mines, and with 22 years in the electrical control field, has been appointed district manager of the Philadelphia area, for Clark Controller Company.

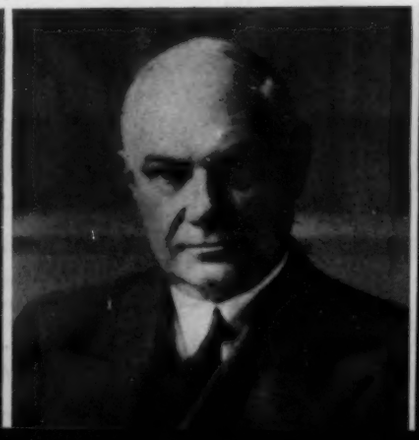
Mr. Hutton's long experience in steel and other heavy industries particularly fits him for his new work in the Philadelphia district.

H. A. Grove has joined the Atlantic Steel Company, Atlanta, Georgia, as metallurgical engineer. Mr. Grove was with Republic Steel Corporation which he joined in 1933 as a member of the research department. Since 1936 he has been mill metallurgist on alloy flat products, specializing on stainless steel sheet and strip production. While at Republic he served as instructor in metallurgy at the University of Akron evening school for six years. Mr. Grove was graduated with a degree in metallurgical engineering from Ohio State University, and was then employed by the Aluminum Company of America at Alcoa, Tennessee from 1929 to 1931. Following this he was associated with Battelle Memorial Institute, Columbus, Ohio.

H. C. Edwards, chief engineer of research and development of Timken Roller Bearing Company, Canton, Ohio, has been made director of research and development succeeding J. F. Leahy, retired. Mr. Edwards has devoted his entire career of 30 years to research and development along automobile, aircraft and diesel engine equipment lines. Born at Sumner, Nebraska, January 10, 1894, he was educated in the public schools of Kearney, Nebraska, and graduated from the University of Nebraska in 1916 with the degree of bachelor of science in mechanical engineering. During World War I he was sent to Washington, D. C.,

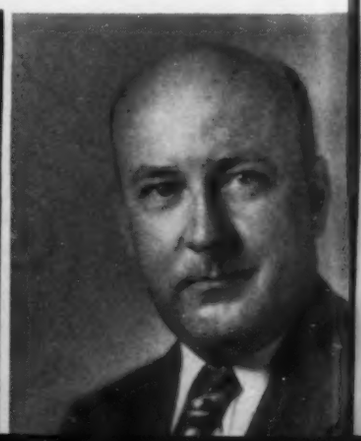
R. S. SHOEMAKER

QUINCY BENT



STUART J. CORT

H. A. GROVE



to work with the Bureau of Standards on the Liberty motor. After the war he became a designer of automobile chassis for the Lincoln Motor Company, Detroit. From there he went as chief designer to the Stout All Metal Airplane Company and built the first all-metal airplane in the United States. Two years later he was back with Packard on water-cooled aircraft engine development for six years, until, 1928. This led to the development of the aircraft diesel engine, for which Mr. Edwards became chief engineer, from 1928 to 1935. In 1935 Mr. Edwards joined Timken Roller Bearing Company as chief engineer of diesel fuel injection equipment until 1941. During the war he was in charge of special radial bearings. In 1943, he was appointed chief engineer of research and development.

Walter F. Greene becomes manager of research and development for Timken Roller Bearing Company, Canton, Ohio. Mr. Greene was born in Canton, Ohio, February 7, 1909, and attended the Canton public and McKinley high schools, before entering the University of Cincinnati, where he studied mechanical engineering. In 1930, he became a draftsman in the engineering department of York Ice Machinery Company. Four years later, he joined Hoover Company, and then, in 1935 came to Timken where he was employed in the experimental department, assisting in the development and testing of experimental methods of bearing manufacture. That same year, he was transferred to the works engineering department as a tool designer, and later, a machine designer. In 1941, he was appointed assistant works engineer in charge of the design of special tools and machines and of the specification, investigation and purchase of all machinery for the bearing factory. Then, in 1945, he was transferred to the newly created division of development and research as assistant manager.

Elwyn T. Gants, for seven years general foreman of Youngstown Sheet and Tube Company's by-products and benzol plant at Campbell, Ohio, has been appointed assistant superintendent of the company's Brier Hill coke plant. He succeeds R. R. Eppley who was appointed superintendent of the Brier Hill coke plant following the death of E. F. Vogel recently. Mr. Gants, a native of Wenona, Illinois, received a bachelor of mechanical engineering degree from the University of Illinois. In 1918 he left Pittsburgh Crucible Steel Company at Midland, Pennsylvania, where he was a hydraulic engineer, to become an efficiency engineer at Youngstown's coke plant in Campbell. A few years later he was appointed general turn foreman of the coke plant and in 1940 was appointed general foreman of the by-products and benzol plant.

Paul W. Pheneger has been appointed superintendent of finishing, packaging, shipping, and traffic for the Carnegie, Pennsylvania, plant of Superior Steel Corporation. Mr. Pheneger was formerly general superintendent of Michigan Seamless Tube Company, South Lyon, Michigan. He is a graduate of Carnegie Institute of Technology.

Harold R. Ryan has been appointed assistant superintendent of the open hearth department of Youngstown Sheet and Tube Company at Indiana Harbor, Indiana. Mr. Ryan joined Youngstown Sheet

Now!
FORGED STEEL
THE LATEST DEVELOPMENT IN
CHIKSAN
BALL-BEARING SWIVEL JOINTS
CHIKSAN has adopted forged steel for all Styles and Sizes to and including 2"...in the following pressure ratings: 1,000 psi, 3,000 psi, 12,000 psi and High Temperature (700 psi, 500° F.). This important development now brings even higher quality to CHIKSAN users everywhere. It is tangible evidence of CHIKSAN's policy for continuous development in the design and manufacture of Ball-Bearing Swivel Joints for all purposes.
CHIKSAN REPRESENTATIVES IN PRINCIPAL CITIES
EXCLUSIVE EXPORT REPRESENTATIVE: CHIKSAN EXPORT CO • Brea, California
Branches: New York 7 • Houston 1
CHIKSAN
BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES
CHIKSAN COMPANY
BREA, CALIFORNIA
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Modern Sawing
with
KLING HIGH SPEED FRICTION SAWS
24" 100-lb. I Beam 28 Seconds
15" 55 lb. Channel 15 Seconds
8" x 8" x 34.3-lb H Beam 10 Seconds
9 Seconds 100-lb A.R.A. Rail
5 Seconds 6½" x 6½" x 19.8 lb. Tee
11 Seconds 8" x 8" x ¾" Angle
10 Seconds 3" Square
15 Seconds 4" Round
11 Seconds 6" O.D. Tube ½" Wall

Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Consult Kling engineers regarding your metal cutting problems. State size of material to be cut. Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

KLING BROS. *Engineering Works*

Punches; Bar, Angle and Rotary Shears; Combination Shear, Punch and Copers; Plate and Angle Bending Rolls; Heavy Duty Grinders

1324 N. KOSTNER AVENUE, CHICAGO 51, ILLINOIS, U. S. A.

and Tube in 1937, going there from National Tube Company at Lorain, Ohio. He first served as observer foreman of open hearth and bloomer at the company's Brier Hill works in Youngstown and also held jobs as first helper, practice engineer, junior and senior melter and turn foreman.

Steve J. Sferra was appointed superintendent of Youngstown Sheet and Tube Company's coupling shop succeeding Thomas C. Thomas, retired. Mr. Sferra was only 14 years old when he went to the plant on Thanksgiving Day 41 years ago and asked for a job. "I told them I was 17" Steve said. "A number of men had taken the day off so I was given a job." A few years later he was appointed foreman and 19 years ago was appointed general foreman.

William Rodder was elected vice president in charge of engineering of Aetna-Standard Engineering Company. Mr. Rodder has been in Aetna-Standard's engineering

WILLIAM RODDER

department for eighteen years, and has been chief engineer for the past nine years.

Dwight F. Benton, general manager, lubricating sales, Standard Oil Company (Indiana), Chicago, Illinois was elected a director of the National Lubricating Grease Institute to fill the unexpired term of L. C. Welch, retired, at a meeting of the NLGI board of directors held in Atlantic City recently.

Thomas C. Thomas, a member of Youngstown Sheet and Tube Company for more than 40 years and superintendent of the coupling shop for more than 18 years, has retired. Mr. Thomas joined the company back in 1907. In 1917 he was made foreman of the coke plant machine shop and three years later became general foreman of the mechanical department. In 1924 he was sent to Evanston, Illinois, as superintendent of a plant Sheet and Tube acquired when it purchased Steel and Tube Company of America. Three years later he returned to Campbell works as superintendent of the seamless tube mills and in 1929 was appointed superintendent of the coupling shop.

Elmer O. Austermiller has been appointed chief engineer of National Tube Company, McKeesport, Pennsylvania. He is a graduate of Rose Polytechnic Institute of Terre Haute, Indiana and started his steel mill career at LaBelle Iron Works (now Wheeling Steel Corporation) at Steubenville, Ohio. Following three years with LaBelle Iron Works Mr. Austermiller went with Universal Portland Cement Company at Buffington, Indiana; Wisconsin Steel works of International Harvester Company at Chicago, Illinois; H. A. Brassert Company at Pittsburgh, Pennsylvania; and Day and Zimmermann, Inc., at Chicago, Illinois and Philadelphia, Pennsylvania. He has been assistant chief engineer of National Tube Company at McKeesport for the past four years.

Owen M. Griffith has been appointed Buffalo district sales manager for Harbison-Walker Refractories Company. Mr. Griffith began his Harbison-Walker career in 1930 as a salesman in the Pittsburgh district

OWEN M. GRIFFITH

sales office, later being transferred to Buffalo. He attended Carnegie Institute of Technology.

Johan C. H. Larsen was appointed factory representative for Adalet Manufacturing Company, Cleveland, Ohio, covering Northern Ohio. Mr. Larsen was formerly with the W. Bingham Company and the Fisher body division of General Motors Corporation. His business background includes sales, purchasing and expediting.

Sigmund W. Stewart has been appointed general purchasing agent and **J. M. Menk,** assistant general purchasing agent of the Vanadium Corporation of America, with headquarters at Niagara Falls, New York. Mr. Stewart was formerly assistant purchasing agent of the Continental Electric Company, Inc., and Mr. Menk was works accountant of the Vanadium Corporation of America.

Ralph C. Moffitt was promoted to the position of assistant to vice president, purchases, of the United States Steel Corporation of Delaware. Upon his graduation from the School of Business Administration at the University of California, Mr. Moffitt joined the United States Steel Corporation organization in the purchasing department of the Columbia Steel Company in San Francisco. On November 1, 1943, he was transferred to Provo, Utah, as purchasing agent, Utah operations.

(*Please turn to page 134*)

Lintern

AIRE-RECTIFIER

Installed on Coke Quench Car

This is the first of a series of 16 installations of Lintern Aire-Rectifiers purchased by one of the country's largest steel companies for use on quench cars, larry cars, coke pushers and door cranes.

It is the first installation of its kind anywhere. The fully enclosed cab replaces the old open cab with its hazards of steam, gas, and hot coke . . . results in safety for men and equipment, and assures better and greater production.

The Aire-Rectifier provides normal temperature in the cab of 80° to 85°, protecting the operator against the high temperatures (running up to 130°), and providing clean, healthful air with the coke dust, steam and SO_2 filtered out.

These Aire-Rectifiers are the only ones specifically engineered for all steel mill and foundry applications, and which cover all requirements with standard models. They are the only make universally used the country over, in all types of industrial applications, the result of long specialization in hot metal cab conditioning.

Write for Bulletin AC-111546.

THE LINTERN CORPORATION

54 LINCOLN AVENUE BEREA, OHIO

Glowlite Signals, Lanterns, Markers, Shock Absorbers for Lamps, Ventilating Heaters, Aire-Rectifiers for Overhead Cranes

What's the Story on Oxygen in Steel-Making Furnaces? No. 3 of a Series { No. 1 was a General Review / No. 2 was on Decarburization

Through the furnace door showing the LINDE Jet Device for scrap melt-down.

LINDE Jet Devices have changeable oxygen nozzles which provide for oxygen flows ranging from 3,000 to 70,000 cu. ft. per hour.

Mowing Down the Scrap

A JET OF OXYGEN AT SUPERSONIC VELOCITY directed against preheated scrap is used to rapidly cut down exposed portions of the scrap pile.

Data have been accumulated on the use of oxygen in more than 7,000 heats in 34 furnace shops with which LINDE has co-operated. When oxygen has been used for direct scrap melt-down, the time of the heat has been reduced appreciably.

The action of the oxygen stream on the preheated scrap is similar to oxygen-cutting. The heat of oxidation of a small amount of metal produces some superheated molten metal. Rapid melting of additional scrap is accomplished by highly efficient heat transfer. The oxygen jet is also used to clear a path for the main burner flame, and thus improve overall heat transfer.

This method was a new idea that LINDE brought into the investigation of the use of oxygen in steel-making furnaces to increase output. The Jet Device, a water-cooled tool conceived and built by LINDE, is used. Oxygen consumption in experiments has averaged only 70 to 100 cu. ft. per ton of charge. Also, the operating time is short, especially in view of the results obtained—only 10 to 30 minutes. This method of direct scrap melt-down warrants thorough examination by the steel industry.

Management and production executives are invited to write for a copy of the factual report which LINDE has prepared on oxygen use in steel-making furnaces. This report also explains the DRIOX high-purity liquid oxygen system and LINDE's work on low-purity gaseous oxygen. Please address Room 308, 30 East 42nd Street, New York 17, N. Y.

Linde
Trade-Mark

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities
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The words "Linde" and "Driox" are registered trade-marks of The Linde Air Products Company

Contract Pipe Cleaning for

Iron and Steel Plants

HEARTH JACKETS « FEED and DISCHARGE LINES
CIRCLE PIPE « FEED WATER LINES to STOVES
WASTE WATER LINES « WATER and
GAS MAINS « SEWERS

A Complete Engineering and Operating Service Specializing In The Cleaning of Pipes and Tubes of All Sizes and All Kinds.

Saves

MAINTENANCE DOLLARS

Whatever your pipe cleaning problems, Pittsburgh Pipe Cleaner experts have the experience and the equipment to do the job quickly, thoroughly and economically. Water supply lines and sewers can be restored to fullest capacity at only a fraction of the cost of replacement and with a minimum of shutdown time.

Plant superintendents know that tuberculation, incrustation and sludge deposits in water cooling lines retard heat transference and are hidden menaces to open hearth and blast furnace efficiency. Make certain that old lines, as well as new, are functioning at top capacity by calling in a Pittsburgh Pipe Cleaner engineer. Our research and development division is ready to serve you in overcoming open hearth and blast furnace pipe cleaning problems.

CLEANING RESULTS

•

10,600 ft.—8 in. Main
Cleaned in 75 minutes
—Removed 60 tons of
dirt—One operation
at
YOUNGSTOWN
OHIO

PITTSBURGH PIPE CLEANER COMPANY

133 Dahlem St., Pittsburgh 6, Pa.

PHILADELPHIA · BALTIMORE · WASHINGTON · NEW YORK · BUFFALO · CHICAGO · CINCINNATI · ST. LOUIS · DETROIT · BOSTON

Two years later he came to Pittsburgh as purchasing representative to handle purchasing for Columbia Steel Company's expansion and reconversion programs in the far west, the position he held prior to assuming his new duties as assistant to vice president, purchases, of United States Steel Corporation of Delaware.

W. H. Bollinger will represent Esterline-Angus Company, Inc., in the Pittsburgh district. Mr. Bollinger graduated from Purdue University in 1933 with a bachelor of science degree in electrical engineering. Since then he has been employed in the engineering and sales departments of the Esterline-Angus Company. During his fourteen years at the factory, Mr. Bollinger has assisted in instrument design, preparation of operating instructions and technical literature, and has engineered instrument applications of a wide variety.

James E. Nichols has been appointed chief stationary engineer by Youngstown Sheet and Tube Company, succeeding F. B. Rathburn, retired. Mr. Nichols, a native of Phillipsburg, Pennsylvania, came from the General Electric plant in Pittsburgh 18 years ago to be assistant chief stationary engineer for Youngstown.

H. A. Bartling, who has been assistant manager of Allis-Chalmers Manufacturing Company's sales department, is now manager of a newly created electronics section, which incorporates sales and engineering functions of the former rectifier section and electronic sales and engineering groups which were previously part of the control section.

Warren W. Scherer, and **Howard J. Ralston** are co-authors of the paper winning the first maintenance classificational award of $3200, in the design for progress award program sponsored by the James F. Lincoln Arc

WARREN W. SCHERER

Welding Foundation. Mr. Scherer is with the Homestead works of the Carnegie-Illinois Steel Corporation in Munhall, Pennsylvania, where he is superintendent of the maintenance division. Mr. Ralston is a maintenance metallurgist at the Homestead works, Carnegie-Illinois Steel Corporation.

Here's What Happens to Your
NON-FERROUS CASTING ORDER AT FALCON

Falcon Bronze is a company owned by the casting specialists who work there. When your non-ferrous casting order arrives — by phone, wire or mail — it comes to the immediate attention of these working-owners. Without departmental routine or other impersonal delay, patterns are promptly readied and production started. Close, expert supervision through each step of production eliminates possibility of your order becoming side-tracked, assures highest quality standards of casting. A final, close check to make sure that every requirement has been met, that flawless casting has been accomplished — and another fast, satisfactory delivery is on its way.

When you need quality castings in a hurry, try the personal attention of Falcon specialists.

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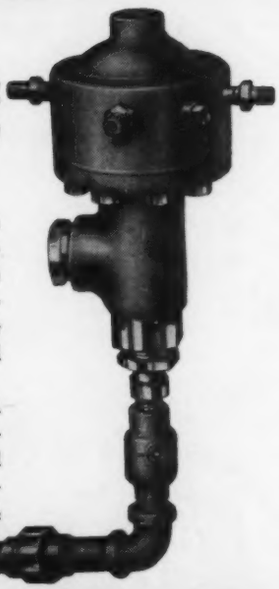
FALCON BRONZE CO.
YOUNGSTOWN 3, OHIO
Established 1890 • Incorporated 1895

Illustrated is an installation of Falcon-produced Kinney Refractory-Lined Tuyere Cooler, U. S. Pat. App. Serial 530153, and Holzworth "Split Nose" Tuyere, U. S. Pat. 1,789,870.

FOR A GROUP OF OIL BURNERS OF SMALL CAPACITY

BLOOM UNIT ATOMIZER



Provides a Method of Burning Small Quantities of Heavy Fuel Oil at Each Burner

The atomizer operates on high pressure steam. It atomizes a reasonable quantity of oil and then divides and distributes this quantity into equal parts, which are delivered to a number of small burners.

An easy system to control. A workable method for a combination oil/gas application to small gas burners. Suitable for oil application to burners requiring 1½ to 3 g.p.h.

BLOOM ENGINEERING CO.
857 W. North Avenue Pittsburgh 12, Pa.

Murray H. Owen has been appointed manager of sales of the General Electric Company's wire and cable division. Mr. Owen's new position includes his old duties as manager of sales of the York wire and cable section as well as the duties of A. E. Newman, formerly manager of sales of the Bridgeport wire and cable section, who has retired. Mr. Owen joined General Electric in Bridgeport in 1922, was later transferred to York, Pennsylvania, as a salesman and in 1930 returned here as manager of York wire sales. He was named manager of sales of the York wire and cable section last year.

Shirley E. Meserve, vice president and general counsel, was elected president of Fluor Corporation, Ltd., Los Angeles, California. Mr. Meserve has supervised Fluor's legal affairs since 1926, being made a director of the corporation in 1937. **W. Earl Dunn,** vice president and general manager, will now serve as executive vice president; **D. W. Darnell,** vice president and chief engineer, was promoted to vice president and general manager; and **J. Robert Fluor,** manager of manufacturing, was named vice president and assistant general manager. **James P. Wiseman,** director of sales, and **T. H. Seavey,** manager of purchases, both were made vice presidents. **Francis E. Fischer** continues as secretary-treasurer. **Robert L. Merrick,** assistant chief engineer, was elevated to chief engineer, and **Foster M. Stephens,** director of development, was advanced to assistant manager of manufacturing.

SHIRLEY E. MESERVE

Kenneth J. Mortimer was made superintendent of the production planning department at Carnegie-Illinois Steel Corporation's South Chicago works. Mr. Mortimer started at the South Chicago plant in 1926 as a pit recorder, in the rolling division. He worked in various jobs in this division until 1936 when he joined the department he now heads. He has been assistant superintendent of production planning since 1944.

L. W. Long is now manager of Allis-Chalmers Manufacturing Company's substation section, formerly known as the mixed apparatus section, which he had served as sales engineer-in-charge.

Patterson S. Weaver was appointed assistant to general superintendent of South Chicago works of Carnegie-Illinois Steel Corporation. A graduate of Ohio State University, Mr. Weaver joined Carnegie-Illinois 14 years ago as an industrial engineer in Pittsburgh district operations. He left the post of assistant superintendent of production planning at the Duquesne plant in February, 1943, to take a similar position at South Chicago works. A few months later he became superintendent of the department.

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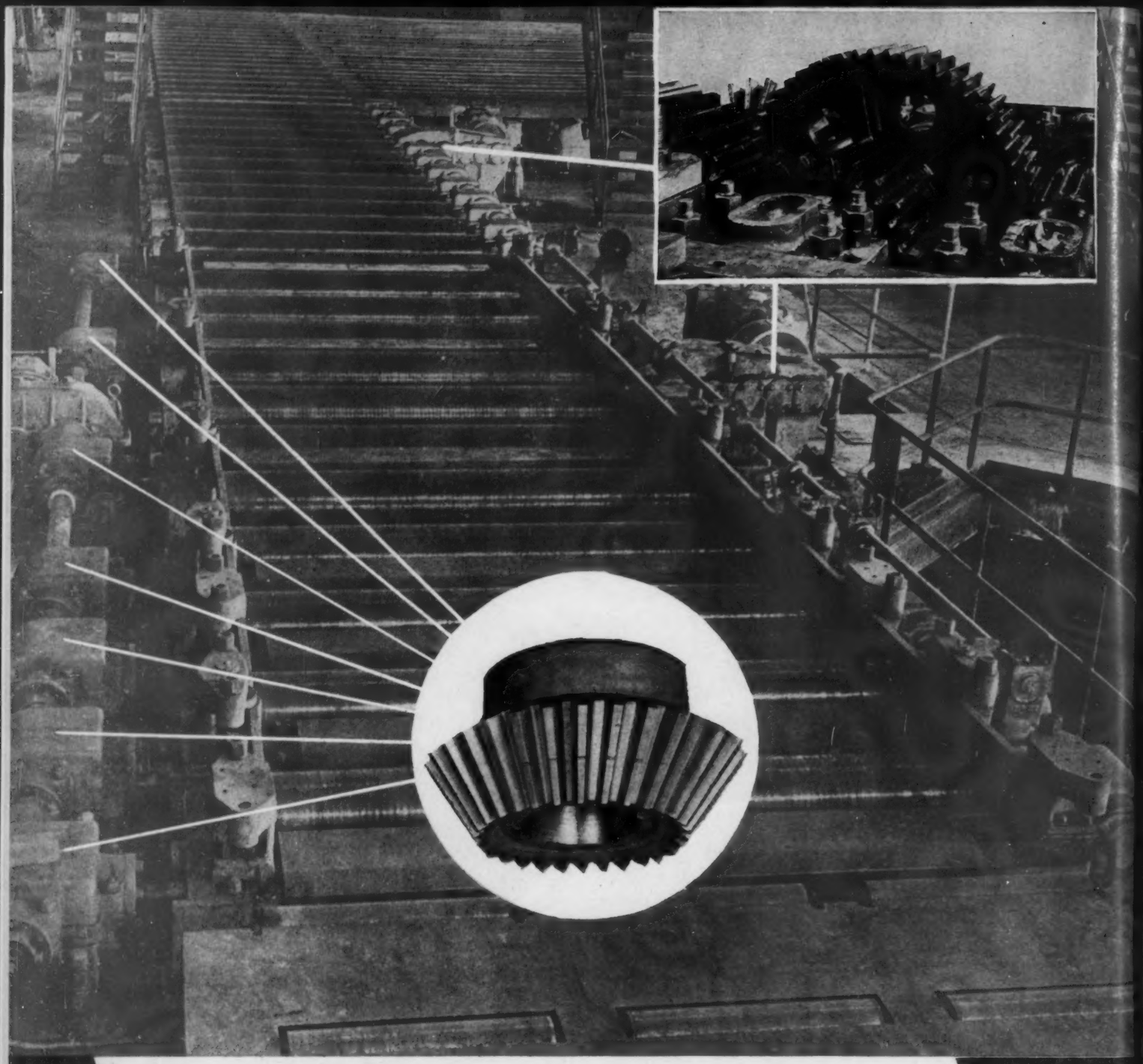

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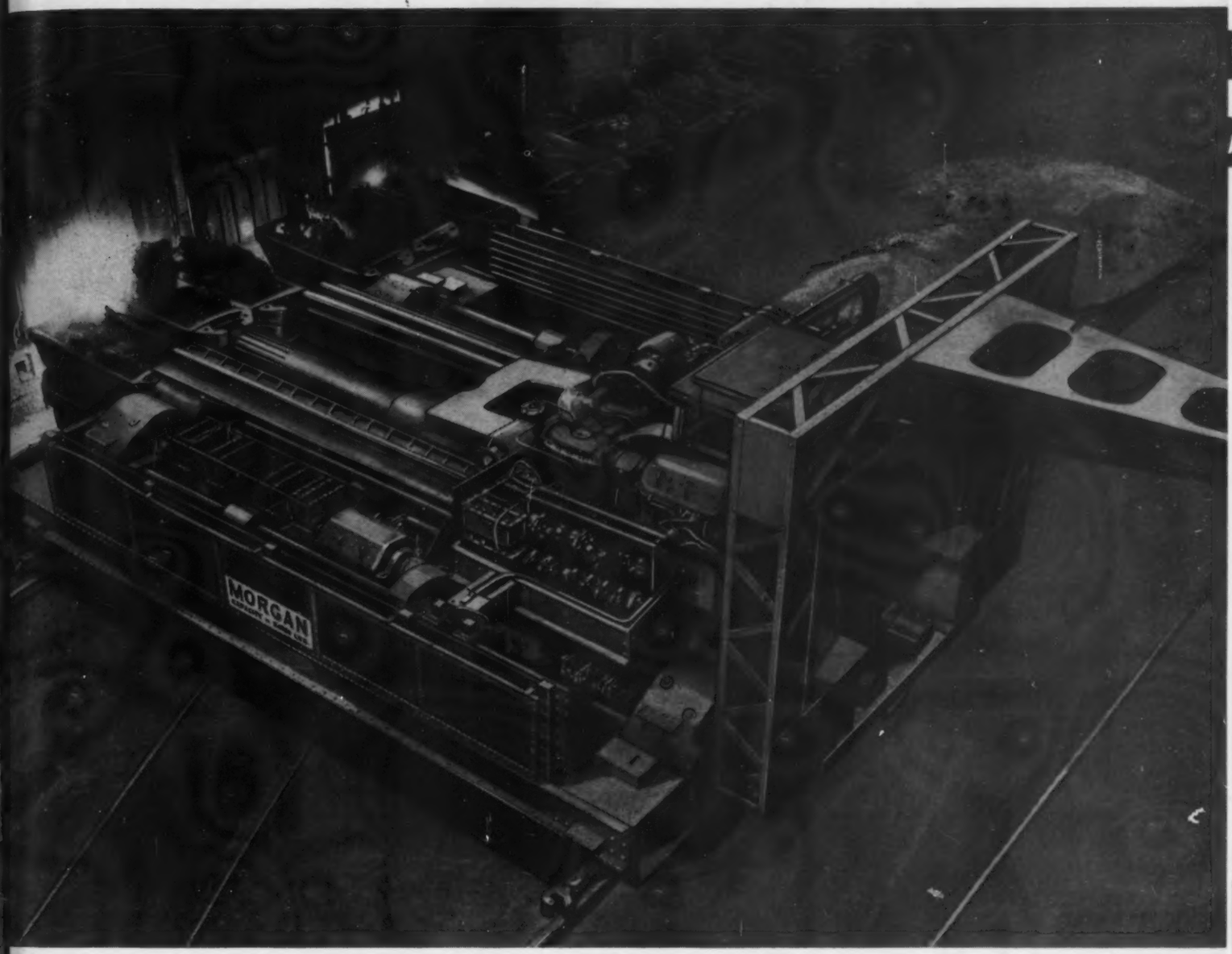
BUILT BY MORGAN Engineering

MORGAN 12-TON LOW TYPE OPEN HEARTH FLOOR CHARGER



Illustrated is one of three Morgan 12-ton 27′-0″ span Box Chargers on this open hearth floor. Trolley frame is a one piece steel casting. Girders are of heavy box section. End carriages are of fabricated welded box construction. Roller bearings are used throughout. Entire machine is of massive construction especially designed for taking heavy thrust loads. Morgan Chargers are built in a wide variety of sizes in both the low and high type to meet varied charging floor requirements.

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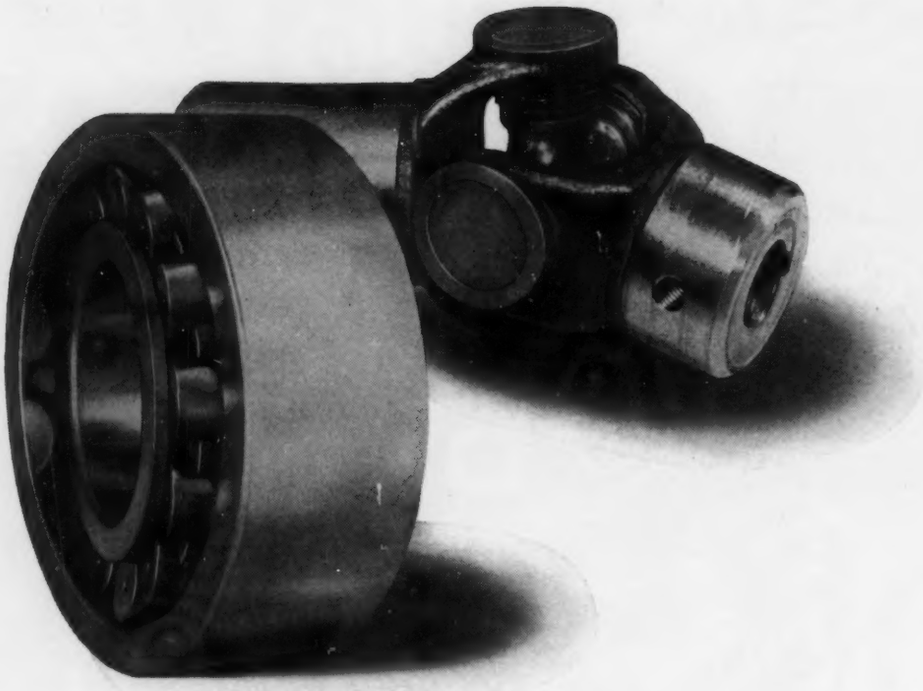

Misalignment accommodated smoothly...

as a universal joint allows out-of-line shafts to rotate freely, similarly the Spherical Roller Bearing accommodates misalignment and shaft deflection. Rapid wear, binding and unusual stresses can be eliminated

By this "universal" self-aligning bearing...

which operates at full radial and thrust capacity under conditions of misalignment which cause premature failure of other types of bearings.

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NOVEMBER, 1947

(1) Worm Gearing

A bulletin is available which describes and illustrates advantages of worm gearing, AGMA service classification, bearing load formulas, quality control and precision manufacturing, selection practice, horsepower ratings, worm thread and gear tooth data for different ratios, dimensions and details of standard worm mountings, worm dimensions, gear dimensions and dimensions of standard flanged rims. (WG1220-5-46) De Laval Steam Turbine Company.

(2) Gear Reducers

Many new sizes and types of enclosed herringbone-gear units for speed reducing and speed increasing service, are detailed and described in a new 68-page book now available for distribution. Link-Belt herringbone-gear reducers are described as efficient, smooth-running, compact, fully enclosed units, designed for heavy-duty industrial service where heavy shock loads and continuous service are encountered. The new book is very complete as to the engineering information it contains. This includes reducer selection data and examples of proper application; dimensions and horsepower ratings; lubrication data; and tables of maximum allowable pull on high and low speed shafts. (1819). Link-Belt Company.

(3) Heat for Metals

A booklet entitled, "Heat for Metals," has just been published describing broad activities in metallurgical research, and the designing and manufacturing of heating equipment for the metal producing and working industries. Subjects include the latest developments in heating equipment for steel mills, the history of the development of gas chemistry and heat treatment; prepared gas atmospheres and heating equipment applications to processing such as gas carburizing, carbon restoration, atmosphere hardening, gas normalizing and annealing, gas cyaniding, gas quenching, gas malleableizing, and atmosphere heating for forging. In addition, standard industrial furnaces, and burner systems and equipment are described. "Heat for Metals" booklet is a ready reference on modern heat treating methods and equipment. Surface Combustion Corporation.

(4) Servo System

A bulletin is available describing an automatic electronic remote control and positioning unit for the control of valves, dampers and other mechanical mechanisms. The basic units which make the complete system can be combined in a variety of ways to produce systems to meet many industrial remote control needs. Three basic units make possible this flexibility: (1) A transmitter from which point any desired position of a remote receiver can be selected. (2) A control amplifier, which responds to the setting of the transmitter and accordingly controls the supply of power to the receiver. (3) A receiver, which moves a load to the selected position. (138). Askania Regulator Company.

(5) Job Study

The quantity and variety of commodities that cross the Grace Line docks in New York City create an unusual warehouse "traffic problem" that is the subject of a job study just published. The report explains in detail how the wide range of merchandise imported and exported via Grace Line, one of the nation's largest shipping concerns, must be carefully and systematically handled to insure maximum efficiency in the use of both dock space and manpower. How this is accomplished with a minimum of time and effort through the use of a fleet of thirty-one fork lift trucks makes an interesting, helpful report for anyone concerned with materials handling in any type of manufacturing plant as well as standard warehousing operations. (Job Study 70). Towmotor Corporation.

(6) Rolling Technique

"Rolling Technique," which has just been issued is one of the most interesting roll and roll design bulletins which have appeared for some time. The bulletin describes in detail roll uses on 21 different sections or classes of material including: rails, tie plates, splice bars, standard beams, "H" beams, universal shape mills, rounds, rods, plate, strip, blooming and billet mills, "Z" bar, angles, seamless tubes, etc. For each type product, a brief description is given of the mill and the rolls which are recommended for each stand. (2090, 64 pages). Pittsburgh Rolls division of the Blaw-Knox Company.

(7) Control Valves

"Pneumatic control valves and controller accessories" has just been issued in a new edition, with all contents revised and brought up to date. Features of the new bulletin include: a color page showing the various identifying enamel finishes offered on "Stabilflo" valves, corresponding with the ASA color code; plates and tables of specifications for control valves, needle type valves, poppet valves and butterfly valves; separate sections on the vernier "Valvactor" for high-accuracy positioning of valve plungers, and on air switches and sub-panels for remote valve control. Information is supplied on the computing of valve sizes, with tables and formulae for determining the size of the correct valve for a contemplated installation. Air filter sets, ventilating dampers, and other accessory equipment are illustrated and described. (277-2). Foxboro Company.

(8) Rectangular Magnets

A new 12-page catalog describing rectangular double-gap electro-magnetic, suspended, spout and plate magnets and wet

type magnets for submerged installations has just been issued. The magnets are applied for the removal of tramp iron to protect equipment such as crushers, grinders and screens; for the prevention of fires and explosions caused by sparks from tramp iron; for purification of non-magnetic products; and for recovery of tools and magnetic scrap. The new catalog describes the applications of these magnets in mining, food, process, metal-working, rubber, textile, grain, and other industries. It includes drawings, illustrations of installations, specification data, and the first printed description of the new self-cleaning rectangular magnet — a suspended magnet equipped with a cross belt which automatically discharges iron. (301-A). Dings Magnetic Separator Company.

(9) Carbon Tetrachloride

Of interest to all carbon tetrachloride users is a new 32-page booklet "Carbon Tetrachloride Properties and Uses." This book contains both technical and general data concerning carbon tetrachloride and is intended to serve as a ready reference book for those using this product. Some of the technical phases discussed are its specifications, physical properties, azeotropic mixtures, vapor pressure-temperature relationship of carbon tetrachloride and other chlorinated hydrocarbons, solubility of water in carbon tetrachloride, stability, action on metals, non-flammability, solvent power, chemical properties, binary mixtures and the testing of carbon tetrachloride. Stauffer Chemical Company.

(10) Pressure Booster

A bulletin on a Hydro-Power hydraulic booster, pressure intensifier which doubles or triples pump pressure in oil-hydraulic circuits, is available. Generating pressures up to 7500 psi, the booster is applicable to both new and old equipment. The bulletin describes operation, lists sizes and dimensional information, and considers booster applications, including schematic drawing of a typical hydraulic booster circuit. Hydro-Power, Inc.

(11) Mounted Wheels

Practical methods for increasing production, improving workmanship and reducing costs with light portable grinding equipment are described in "Mounted Wheels," a new 32 page handbook just published. The wide range of wheel shapes and sizes, the variety of abrasives and coated abrasive discs, sleeves and cartridge rolls available for use on light-weight, high-speed portable grinders are discussed and depicted. Photographs and diagrams are used to provide correct identification and selection, to illustrate careful handling and storing and to show proper and efficient applications. Carborundum Company.

(12) Car Shakeout

A new bulletin has been issued completely describing and illustrating the Robins car shakeout. The bulletin not only presents the statements of the manufacturer, that the car shakeout unloads hopper-bottom cars in only a few minutes, with only two men, without any manual labor, even with frozen material, but offers substantiating evidence in the form of reports from owners of the equipment relating their savings in unloading such substances as coal, petroleum coke, limestone, ore and other bulk materials, even when they are frozen. Two pages are devoted to proof of the statement that the car shakeout can be handled by any hoist that is able to lift a 5-ton load, the proof consisting of a spread of photographs showing rigs, some of them quite elaborate, one of them made from old telegraph poles with planks as stiffeners while a winch on a truck served as the hoist. (128-A). Robins Conveyors division of Hewitt-Robins, Inc.

(13) Radiation Sighting

A nomograph which determines correct sighting angles and locations for radiation measurement of extreme processing temperature is available. The nomograph will replace, said John R. Green and Joseph Adams, designers, former hit-and-miss methods for defining correct positions, such as height and angularity of a sighting element. As a result, it was added, an accurate indication will be obtained of the area being measured without resorting to the necessity of working out the problem mathematically. The original purpose of the nomograph was to provide a simplified means of correctly positioning their Radiamatic radiation detector to sight on the top course of checker-brick in regenerative furnaces. The nomograph, further developed beyond the original plan, can give speedy knowledge of correct sighting angles and locations which, it is added, will favorably affect fuel economy. Brown Instrument Company.

(14) Pickling

How certain specialized acid inhibitors and neutralizing materials promote cost-savings and improved-quality production in the pickling of iron and steel, is the subject of a special illustrated service report just published. This service report provides valuable data on this manufacturer's pickle control materials used in the pickling of high and low carbon and alloy steel bar, round, sheet, tube and wire stock. A feature of this report is a special section containing graphs showing the action of these acid pickling inhibitors in reducing metal loss. A comparison chart and table show how these materials reduce acid consumption and extend life of pickling solutions by lowering iron sulphate build-up. Supplementary data includes instructions for making up, controlling and maintaining sulphuric acid and hydrochloric acid pickling solutions. Report also stresses the importance of neutralizing materials in protecting pickled surfaces against rust, and in removing smut, streaks, and stains so as to improve surface appearance and facilitate subsequent fabricating operations. Oakite Products, Inc.

(15) Corrosion Resistance

A complete 12 page manual on the corrosion resistance, proper installation and use of acid proof sinks, sink strainers, traps, and sanitary pipe and fittings has just been issued. It will be of interest to all who must handle corrosive wastes. Contents: composition; physical characteristics; corrosion resistance; and other industrial applications. A price data bulletin has also been issued. It lists all items available for prompt delivery. Both manual and bulletin are available. (703 and H). Duriron Company, Inc

(16) Temper Designations

Rapid metallurgical advances and improved fabricating techniques during the past few years have served to magnify the inadequacies of the present Alcoa temper designation system for aluminum and the aluminum alloys. In order to overcome inadequacies in the present system and also to provide a definite pattern for future developments, a revised system of aluminum alloy temper designations has been developed by Alcoa. This new system, based on manufacturing techniques, becomes effective on all shipments made on and after January 1, 1948. A booklet is available describing Alcoa temper designations for cast and wrought products. (AD-161). Aluminum Company of America.

(17) Air-Operated Controllers

A new catalog, "Air-Operated Controllers," containing valuable information on instruments for the automatic control of industrial processes, is now being offered. Incorporated in this catalog are complete and accurate descriptions of control instruments for temperature, pressure, flow, liquid level and humidity. Many photographs, schematic drawings and diagrams illustrate the construction and principles of operation of all instruments described. (8905). Brown Instrument Company.

(18) Rotary Hand Pump

A bulletin is obtainable describing a new, meter-equipped, rotary hand pump. The unit is built for fueling or dispensing of liquids up to 10,000 SSU viscosity. The meter registers to 8 gallons and is equipped with a 9999 gallon totalizer. The unit includes a 40 in. suction pipe with bung attachment, 8 ft oil resistant discharge hose and aluminum nozzle. The 10 gpm pump features include an aluminum rotor, graphite-carbon vanes, cadmium plated packing nut and stainless steel springs. (3001). Bowser, Inc.

(19) Adjustable Speed Drive

A bulletin covering all-electric adjustablespeed drives in the higher horsepower ratings is yours for the asking. Introduced in 1939, the V*S drive system has since the war been developed in the 40-200 horsepower range for broader application of its advantages of stepless speed changes over unlimited ranges, controlled acceleration and deceleration; reversing, jogging, threading and quick stopping, all by convenient pushbutton control. Bulletin No. 311-A describes these features and their applications, and details the equipment involved for operation from a-c 2-phase or 3-phase 60 cycle, 220, 440 or 550-volt circuits. Reliance Electric and Engineering Company.

(20) Slurry Pump

Just published is a 16-page bulletin on new slurry pump with wear parts centrifugally cast of abrasion resistant diamond alloy. Complete, detailed description, engineering and pumping data, selection chart, dimensions, assembly drawings and parts list are included. The bulletin demonstrates

in general the outstanding mechanical features of the pump, including the characteristics of diamond alloy which specifically withstands abrasion and corrosion and gives harder, better, longer wearing parts, and increases pump life and efficiency. Pettibone Mulliken Corporation.

(21) Induction Heating

Valuable information on forging, upsetting, spinning, hardening, etc. with induction heating is offered in a new bulletin now available. This 12-page, well illustrated bulletin includes data on the principles of induction heating, advantages, sources of power, furnace controls and auxiliaries, types of induction heaters, typical coils and work stations. Also illustrated are many applications of induction heating now in use throughout the world. (13-A). Ajax Electrothermic Corporation.

(22) Overhead Cranes

Built in a range of capacities of from 3 to 150 tons, a line of electric traveling cranes is described in a bulletin recently issued. The liberally illustrated 28-page publication contains detailed information on these cranes. Sections describing the bridge, rotating axle roller bearing end truck, center bridge drive, trolley, brakes, hook blocks, cage and motors are included. Victor R. Browning and Company, Inc.

(23) Laminated Plastics

A new 64-page booklet on "Textolite" laminated plastics has just been published. The booklet contains complete information on the manufacture, application engineering and properties of all types of laminated applications. It lists 44 different grades of the sheet material along with their electrical, physical and mechanical properties.

Other sections of the booklet contain all necessary information on tubes and rods, bearing materials, silent gears, decorative surfaces, translucent sheets, nameplates, molded-laminated plastics, low-pressure laminated plastics, methods and fabricating laminates and ordering instructions. Plastics division of General Electric Company.

(24) Mixed Flow Pumps

A mixed flow type pump is described and illustrated in a new 24-page bulletin, furnishing information to pump users whose applications require moving or removing of water in capacities up to 220,000 gpm. The mixed flow pump complements the "Hydro-Foil" pump line which includes a propeller type pump also fully described in the new bulletin. The addition of the mixed flow design now offers the measurable advantage of flexibility where huge volumes of water are to be handled under varying conditions than might otherwise be undertaken by large capacity pumps. Described advantages of the mixed flow type pump, embodying essential characteristics of both centrifugal and axial flow pumps, include its ability to move liquids against maximum heads with minimum submergence, adaptation to shallower sumps, utilization of higher speed motors against medium heads and installation in minimum space. (B-148). Peerless Pump division of Food Machinery Corporation.

(25) Tube and Tile Wall

There have been many radical developments in water wall designs for boilers in the last few years. Each different type of water wall requires special treatment for retaining the gases within the furnace. A bulletin is available describing a solution for one of the problems confronting the builders and operators of water walled boilers in utility and industrial plants. Among the advantages are: 1. Sectionally supporting the tiles in units with offset expansion joints so as to absorb differential expansion between tubes and refractories, positively holding tiles against the tubes, eliminating outward movement of tiles from ordinary pulsations and vibrations. 2. Universal slotted anchor tiles eliminate field drilling or cutting of the tiles, thus reducing installation labor. 3. The design provides a novel means of securing insulation in place and permitting the use of blanket insulation instead of dense blocks. 4. The outer casing or finish coat is entirely independent of the inner insulation, thus avoiding checking and cracking. 5. No steel casing required. 6. Tubes can be replaced without dismantling wall. (B-547). George P. Reintjes Company.

(26) Unit Heaters

Recently published is a 12-page illustrated bulletin (No. 516) describing the new "Counterflo" heater designed for industrial and commercial use. This bulletin outlines in detail the successful application of stainless steel to combustion chambers used in this self-contained, direct fired, warm air heating unit. Other new aspects discussed are: more efficient combustion by the "Counterflo" method; ready fuel convertibility from oil to gas or vice versa; elimination of refractory lining within the combustion chamber. Bulletin 516 stresses the longer life expectancy, lighter weight, compactness and wide range of application of this heater. Dravo Corporation.

(27) Feed Water Control

New performance data is included in a revised bulletin "Bailey three-element feed water control." This bulletin lists a number of advantages of the three-element system, shows chart records illustrating operation under difficult conditions and gives a large list of users. Among the advantages listed are: 1. The avoidance of serious water level fluctuations as the system anticipates and corrects variations in level before they appear by measuring and equalizing the steam flow-water flow relationship. 2. Excess pressure variations do not seriously affect the operation of the system. 3. The control may be applied to the feed water pump to regulate its speed thereby controlling the feed water flow. 4. Either a constant level or one which varies with rating may be had as desired. 5. Complete performance records are made by the meters used to actuate the control system. (105-B). Bailey Meter Company.

(28) "Looking Beyond . . . .

. . . . the Price Tag," a new booklet published by the Electric Industrial Truck Association, is being distributed by its member companies, the manufacturers of approximately 90 per cent of the storage battery-powered industrial trucks, storage batteries and battery charging equipment in the United States. The booklet stresses the importance of interpreting the value of such equipment in terms of dependability, handling speed, low operating cost, safety for workers and freedom from noise, fumes, and odors. A discussion of basic requirements of mechanized material handling systems, and the importance of continuity once the flow of materials is mechanized, begins the text. Cartoon illustrations point up the main factors in industrial truck selection.

(29) Silent Gears

A booklet is available describing nonmetallic gear materials of two types, known as Fabroil and Textolite. Fabroil gears consist of compressed cotton fibres, held together by steel shrouds and threaded studs. Textolite gears consist of woven

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fabric laminations held in compression by a phenolic resin. Although, in many instances, the two types may be used interchangeably, Fabroil is generally preferred for heavy-duty applications and Textolite, because of its lower cost in the smaller diameters and narrower faces, has wider usage for relatively light-duty gears. Textolite is also used when the greater overall face width of Fabroil due to shrouds and clearance, exceeds available shaft length. (CDP-549). Plastics division of General Electric Company.

(30) Short-Circuit Protection

A booklet is available describing "Limitamp" control, telling how in less than one-quarter cycle EJ-2 fuses in this control can cut off a rise in current from a short, and clear it in one-half cycle, long before the short has time to harm the contactor or motor. The control consists of an airbreak contactor (the motor starter), and EJ-2 fuses (the short-circuit device). They are mounted in separate compartments of one, all-steel cabinet. (GEA-4247). General Electric Company.

(31) Fume Problem?

If you have a department where corrosive or dangerous fumes require constant removal you can increase production by installation of an exhauster which will stay on the job. This is described in a new booklet that is available to you. These exhausters give from 3 to 13 times as much service as metal fans, on corrosive fume jobs. The rotor and entire inside of housing is coated with rubber by the exclusive "Vulcalock" process. (RL). Buffalo Forge Company.

(32) Pressure Recorders

A bulletin is available describing a dependable instrument that is proving itself invaluable to the steel industry, for maintaining proper atmospheres in soaking units, annealing furnaces, open hearth furnaces, slab mills, and any place where an accurate record of draft, pressure or differentials is required. Step No. 1 toward getting the benefits of this modern quality control is to get the facts about it. (43-586). Hays Corporation.

(33) Oxygen

Management and production executives are invited to make use of a factual report on oxygen use in steel-making furnaces which is available to them. Only the first chapters of this story have yet been written, promising though they appear. To date Linde has cooperated with steel companies in obtaining data on more than 6000 heats in 34 furnace shops as a part of an experimental program on oxygen use in steel-making furnaces. From all these data the basic fact stands out that the periods of scrap melt-down and of refining can both be shortened appreciably. If you want to keep up-to-date on oxygen use in steel mill furnaces, we suggest that you obtain this booklet. Linde Air Products Company.

(34) Mass Lubrication

A booklet is yours for the asking describing "Centro-matic" lubricating systems. Specifically engineered for flexibility of application, simplicity of installation, and dependable operation, these single line centralized lubricating systems deliver oil or grease to bearings by positive displacement, under line pressure, providing greatest assurance of proper lubrication — in seconds instead of hours. (801). Lincoln Engineering Company.

(35) Speed Reducers

A bulletin describing "Speedaire," a new fan-cooled worm-gear speed reducer, is yours for the asking. The booklet explains why "Speedaires" will do more work because it is fan-cooled, will deliver up to double the horsepower of standard worm units of equal frame size, at usual motor speeds. It can be installed economically on many applications where other types have been used heretofore, giving you the advantages of a compact right-angle drive. (300). Cleveland Worm and Gear Company.

(36) Cutting Torches

Complete information about a versatile torch, with its full complement of tips, is available to you in two bulletins recently announced. This torch can be used for all conceivable types of cutting operations by means of many interchangeable types of cutting tips. (ADC617) and ADG1098). Air Reduction.

(37) "Lubrication . . .

. . . in Forging Operations" is the title of an article that appeared in a recent issue of LUBRICATION which is available to you upon request. This article is a comprehensive review of the use of lubrication prepared with much thought. All lubrication engineers and supervisors interested in the subject of lubrication should read this article. Texas Company.

(38) Distribution Transformers

A booklet is available on a new distribution transformer, 25 kva and below, 14400 volts and below, single phase, 60 cycles. Among the features of this transformer are the wound-core of cold rolled steel, stud type sidewall issuing high voltage bushings, metal enclosed bushing gaskets, and bushing insulating caps. The booklet is complete with descriptive data, as well as interior and exterior photographs. Mechanical data covering weights and dimensions for the entire range is included. (1147). Pennsylvania Transformer Company.

(39) Centrifugal Castings

Here is a really worthwhile little booklet on centrifugal castings. Included in the booklet is a table containing various commercial specifications and data on properties and uses of alloys, bronzes, copper, tin, lead, zinc and cast iron alloys. All engineers and maintenance supervisors should have this booklet in their files. (143). Shenango-Penn Mold Company.

(40) Abrasive Wheels

Charles H. Besly and Company have recently issued a new pocket-sized 48-page handbook for industrial users of abrasive wheels.

The new booklet explains the advantages of Steelbac grinding discs, a bolted-on product. Reasons for perforations in the discs are clearly outlined and a full explanation for the use of Resinoid bond is given.

Following this section is a standard marking system chart for Besly-Titan abrasive wheels and a series of price list tables. Other informative subjects covered include (1) types of grain used in making these abrasive wheels, (2) prosity control and (3) types and uses of coolants.

The concluding section of the booklet includes photographs and descriptions of five wet Besly grinders, two dry grinders and a piston ring finishing machine.

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Rotary Swaging Machine

6000 HAMMER BLOWS OF INFINITE FORCE PER MINUTE

- The dies and hammers rotate around the work, which is held stationary, quickly swaging it to desired size and shape.
- Built to handle the severest work with capacities up to 14 inches in diameter.
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- Handle hot or cold work.
- Readily equipped with a variety of feeding devices.
- Cast alloy steel drum mounted on base and bolted to front housing.
- Timken bearings take spindle thrust. Radial ball bearing in rear of flywheel.
- Alloy steel forged, heat-treated and ground spindle.
- A taper fit is used for the flywheel which is further secured by a split nut and key.
- Hammers, rolls and inner ring of heat-treated alloys.
- Motor is mounted over the machine on an adjustable bracket, the power being transmitted by V-belts.

WRITE FOR DESCRIPTIVE LITERATURE.

THE ETNA MACHINE CO., 3404 MAPLEWOOD AVE., TOLEDO 10, OHIO

(*Continued from page 127*)

ing to the general store of technical knowledge.

Investigative activities will be projected along two general lines. First, the manufacturing research department will seek the most economical method of manufacture for products already in production in the manufacturing lines. Second, it will seek the most economical method of manufacturing new or improved products coming into the line from design engineering groups.

The objective contemplated by the development of manufacturing standards has as its goal more than the mere accumulation of data showing the best and most economical method of manufacturing. The data accumulated through research will be classified and codified. They will be presented in a form which can be made available to all company manufacturing operations. The standards will thus become a method of establishing uniformity of practice and method from plant to plant within the Harvester Company wherever that is desirable.

The third major specific objective, keeping abreast of all developments in the manufacturing world, is a measure to insure that advances in manufacturing techniques by others outside the company does not escape the notice of those within the company charged with the responsibility of producing the best possible product at the lowest possible cost.

ALLEGHENY LUDLUM ANNOUNCES AWARD WINNERS

The Allegheny Ludlum Merit Award, consisting of the President's Medal, a citation and $1000 in cash, was awarded by the company's board of directors to Glenn E. Hilliard, (right center), manager of Allegheny Ludlum's Brackenridge, Pennsylvania, plant open hearth department, and Robert T. Eakin, (left, center), plant manager of the carbide alloys division, located at Detroit (Ferndale), Michigan. Medals were presented by H. G. Batcheller, (left), president, and W. F. Detwiler, (right), chairman of the board. Mr. Hilliard won his award for developing techniques for using oxygen as a carbon reduction agent in open hearth steelmaking. Award to Mr. Eakin was based chiefly upon his work with Joy Manufacturing Company in the development of coal mining bits tipped with sintered carbide, thereby increasing production of machine mined coal.

PRESENT TRENDS IN NICKEL ALLOYS

▲ A heavy demand persisted this year for alloys of all types containing nickel to satisfy the needs of the metal industry in which high production has been the keynote. A number of trends were observable which reflected the increasingly exacting demands of industry for better performance from all kinds of equipment, tools and appliances.

Widespread use of alloy steels containing nickel has continued throughout the year. The railroad industry has been particularly prominent in using low alloy high strength structural steels to save weight on new rolling stock, by taking advantage of the improved strength, abrasion resistance and resistance to corrosion offered by these steels in the rolled condition. Most of the high strength steels employ nickel in amounts ranging from about ½ to 2 per cent, are readily cold formed and welded, and find extensive use in transportation equipment and other applications in which weight saving is an important consideration.

Triple alloy steels of both carburizing and direct hardening grades have been almost exclusively adopted by the tractor industry for all highly stressed applications; the automotive and machine tool industries are also prominent users. A considerable market has developed for hot coiled and leaf springs because of the higher quality surface conditions and superior toughness obtainable with triple alloy steels containing from .50 to .65 per cent carbon. The American Iron and Steel Institute during the year established as one of its standard alloy steels, a free-machining variety of low alloy, triple alloy steel, known as 8641. It is especially well suited for automatic screw products and combines a high degree of machinability with the good properties of alloy steels.

One of the largest consumers of nickel-containing steels has been the automotive truck and bus industry where the demands for high strength and toughness require the use of various heavily alloyed steels containing combinations of nickel and molybdenum, and nickel, chromium and molybdenum.

Recently developed low carbon high nickel steel, containing 8½ per cent nickel, shows considerable promise for use in the petroleum industry for sucker rods and drill pipe. The excellent mechanical properties developed by this steel in the normalized and drawn condition also are of advantage in this application. Another important trend in the petroleum industry has been the use of relatively highly alloyed steels for drill pipe operating in deep wells. The long strings of rod which must be handled in such wells require the use of nickel-containing steels which develop high tensile strength when treated by normalizing and drawing.

Piston rods of drop forging steam

(*Please turn to page 146*)

IN STACKS—
NEW OR OLD

PREVENT CORROSION ...BOOST THE DRAFT

WITH

LUMNITE LININGS

Three 150-ft. Steel Stacks at a large power station. First stack lined with LUMNITE in 1941, second in 1943, third in 1945.

A LUMNITE lining provides thorough protection against the attack of corrosion and heat in a steel stack. It boosts the draft by keeping gas temperature up . . . gives protection from secondary combustion, high-temperature flue gases and overloading. It resists the attack of condensate and sulphurous gases.

The insulating, corrosion-resistant lining is ready for service 24 hours after installation.

FOR OLD STACKS—A LUMNITE lining, shot on with a gun or plastered in place over wire-mesh reinforcement, strengthens the old shell. By providing protection against heat and corrosion, the lining renews the stack for long continued service. The quick lining job gets the stack back at work with minimum time out for reconditioning.

FOR NEW STACKS—A relatively thin lining of LUMNITE heat- and corrosion-resistant concrete will protect the steel indefinitely. The LUMNITE lining placed over mesh reinforcement is jointless, permits no "breathing." Gases or condensate cannot deteriorate the steel. This lining has high structural strength, high heat-resistance and low thermal conductivity.

Write for New Booklet "Concrete Linings in Steel Stacks"

Lumnite Division

UNIVERSAL ATLAS CEMENT COMPANY

UNITED STATES STEEL CORPORATION SUBSIDIARY

135 EAST 42nd STREET • NEW YORK 17, N. Y.

(*Continued from page 144*)

hammers sometimes have given short life because of the exceptionally severe impact and vibrational stresses imposed in service. In one case low carbon 3½ per cent nickel-molybdenum steel, oil quenched and tempered to a hardness of 200 Brinell, improved the average life from one week to over 200 days.

Cast alloy steels containing nickel are extensively used in railroad equipment, steel mill equipment, excavating machinery and similar fields in which strength in heavy sections and toughness are requisite. They also are in substantial use in applications subject to both low and high temperature service. Low alloy nickel-chromium-molybdenum cast steels are finding considerable use for parts operating at 950 to 1000 F, not only because of their strength but because of their resistance to deterioration by graphitization over long periods of time at these temperatures. For applications involving exposure at sub-zero temperatures, castings containing about 3½ to 4 per cent nickel with less than .15 per cent carbon, are generally employed to avoid the brittle behavior which often characterizes other steels at low temperatures.

The high volume of production of stainless steels achieved during the war years has continued in the post-war period. Ingot production of over 500,000 tons was reached in each of the years 1945 and 1946. Based on the present outlook equally high volume, or more, is predicted for the year 1947.

Industry looks forward to further expansion in volume and scope of uses in the future, and is continuing its research and development activities to provide a better knowledge of fabricating procedures and a broader consumer appreciation of the economies offered by the stainless steels in terms of lowered costs of maintenance, repairs and replacements.

The record high rate of nickel anode production during 1946 included some refilling of tanks which had been depleted by war demands. The fact that the 1947 production will be higher than the 1946 record is a truer indication of the increase in the actual use of nickel for plating.

The automotive industry is still the leader in the use of nickel for plating purposes and is outstanding among a host of diversified fields. Almost all fields are showing either an increase or a favorable resumption of pre-war use. Preliminary examination of large-scale exposure tests by technical societies and specific tests by interested companies have reaffirmed the value of heavy nickel layers under chromium in atmospheric corrosion resistance. Partially as a result of this, heavier nickel plates are being used by the automotive industry on areas exposed to the atmospheric elements.

COMPLETE SLAB FURNACE FOR IRVIN STRIP MILL

▲ An important part of the major expansion and modernization program of United States Steel now is well under way at the Irvin works of Carnegie-Illinois Steel Corporation, where capacity to produce much needed steel sheets and tin plate will be increased by approximately 300,000 tons annually. The first unit to be completed in the expansion program of this United States Steel subsidiary's plant, is a new slab heating furnace for the 80 in. hot strip mill, the basic mill through which all steel is rolled before being processed into finished sheets and tin plate.

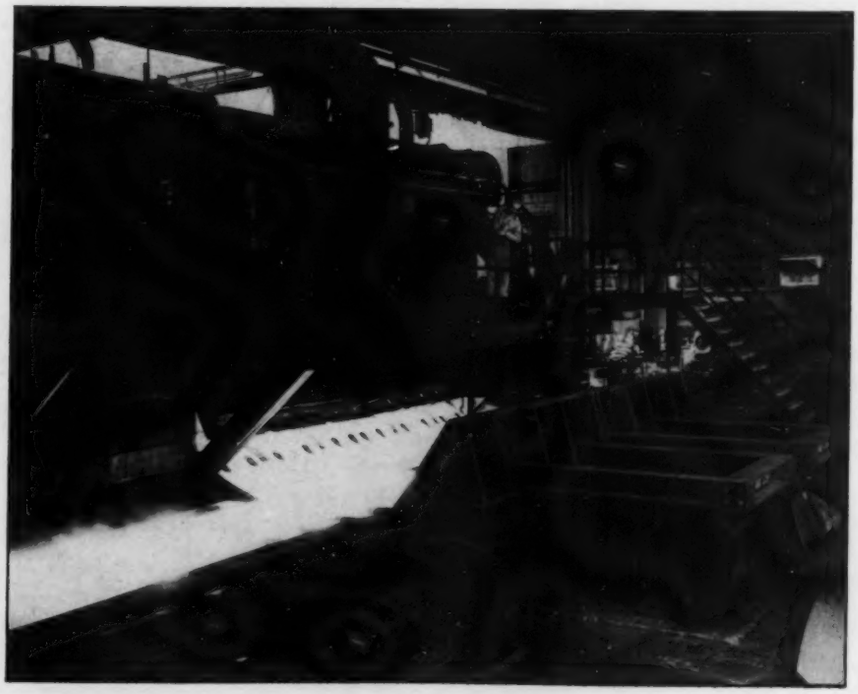
The capacity of the mill is being increased not only by installation of the new furnace, but by rebuilding the existing three furnaces, improving of handling facilities and enlargement of the slab storage building. New pickling, cold reducing, annealing, temper rolling, shearing and tin coating facilities together with additional utility and service facilities also are being provided. Two large buildings are now in the process of erection to house a new galvanizing division which will manufacture galvanized and long terne sheets with modern, continuous coating facilities and forming equipment.

$850 PRIZE CONTEST

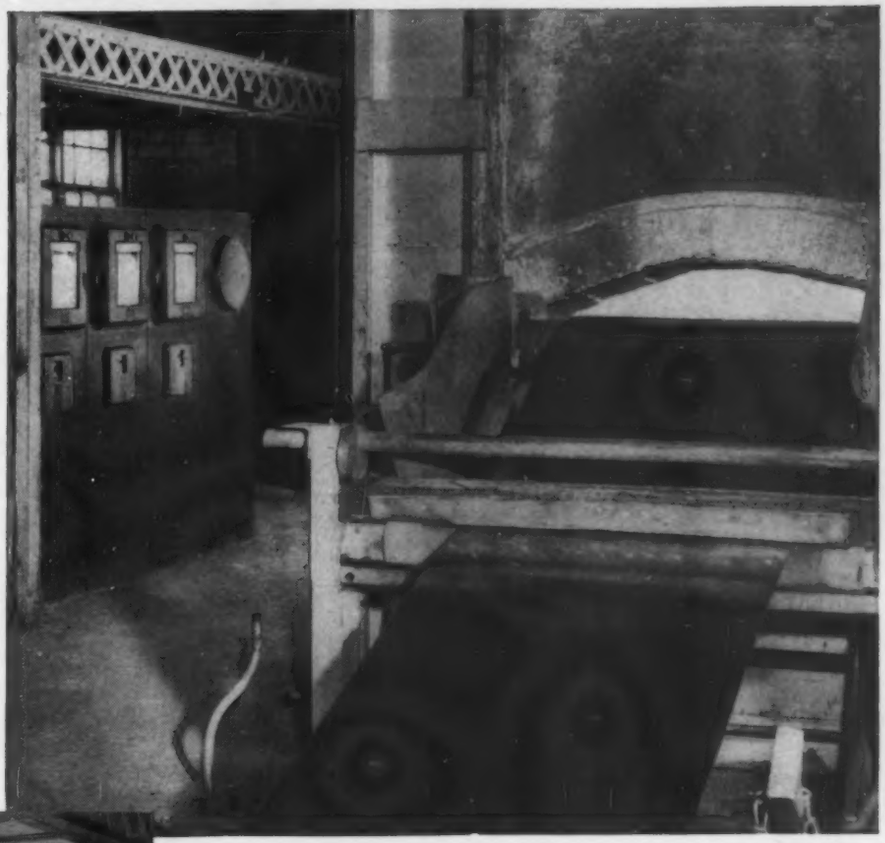
Pennsylvania Transformer Company is conducting a name contest to find a name for its new wound-core distribution transformer. $850 in prizes are being awarded: $500 first prize for the winning name, $250 second prize, and $100 third prize. Closing date is midnight, December 15, 1947. Entry blanks are available and can be secured by writing to Pennsylvania Transformer Company, Box 6208, Pittsburgh 12, Pennsylvania.

(*Please turn to page 150*)

Skidding out of the new No. 4 reheating furnace onto Irvin works' 80 in. hot strip mill, this eighteen foot slab will be rolled into a 2000 foot coil of steel in two minutes. This new slab heating furnace is part of an expansion program which will step up Irvin works' hot strip mill capacity by approximately 300,000 net tons annually when the three original reheating furnaces have been rebuilt.



Stainless Anneal Gets DEPENDABLE Control From Team of MICROMAX Pyrometers



Stainless steel strip (see right) is annealed to extremely close tolerances in a three-zone Tate Jones continuous annealing furnace at the Washington Steel Corporation, Washington, Pa. So critical are temperature limits that each zone — preheat, soak and cooling — is regulated by a separate Micromax Controller (see below), which truly and continuously proportions the fuel supply to the heat demand. As a final check, temperature of strip leaving the furnace is recorded by the round-chart Micromax. The precise control thus obtained helps to assure high production and uniform quality of steel.

WHEN a furnace's output is worth thousands of dollars a day, production can profit greatly by "teamwork" temperature control of Micromax Pyrometers.

Used with the three-zone furnace shown here, for example, are two different Micromax models — strip-chart and round-chart — using two types of temperature detectors — Rayotube radiation element and thermocouple. Each instrument independently performs its assigned part of the control job; yet all combine to hold the entire annealing operation at top quality and volume.

Micromax Recorders and Controllers are able to work smoothly together as a team because each is a highly accurate, sensitive instrument embodying the same basic measuring mechanism. Each model can be supplied for use with a thermocouple or with a Rayotube, as above, or, for lower temperatures, with a Thermohm (resistance thermometer). Regardless of the type of primary element, each instrument has the same quality of micro-responsiveness, which makes the recording pen and control valve move with the least significant temperature change, to hold temperature accurately within the desired limits.

For a copy of our Broadside N-33 or a personal call, send details of your problem to Leeds & Northrup Company, 4942 Stenton Avenue, Philadelphia 44, Pa.

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LEEDS & NORTHRUP CO.

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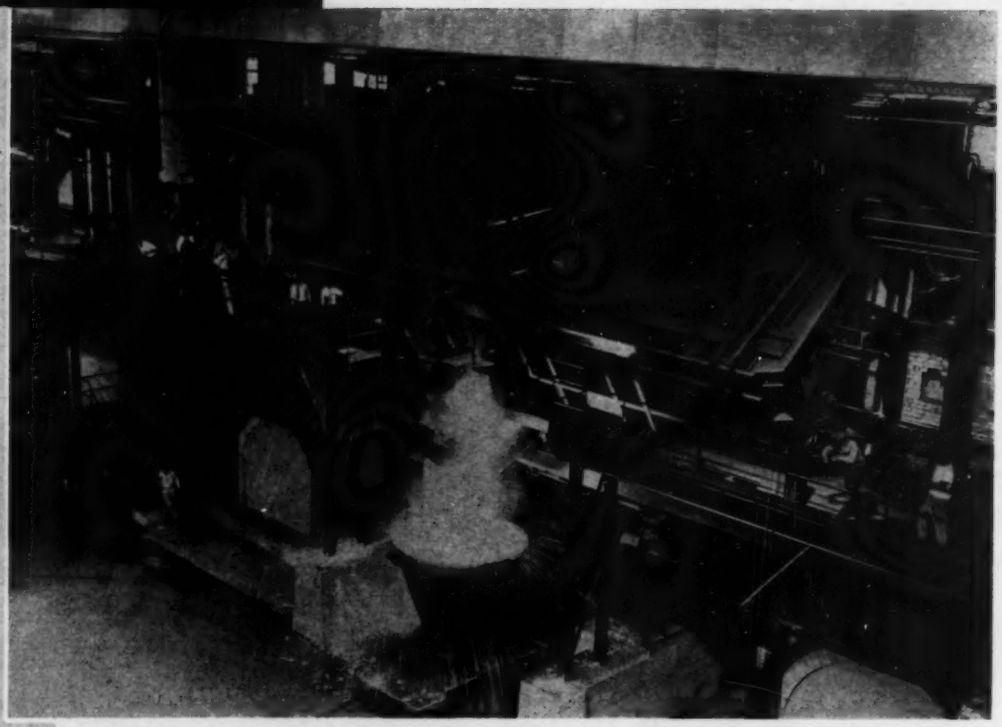
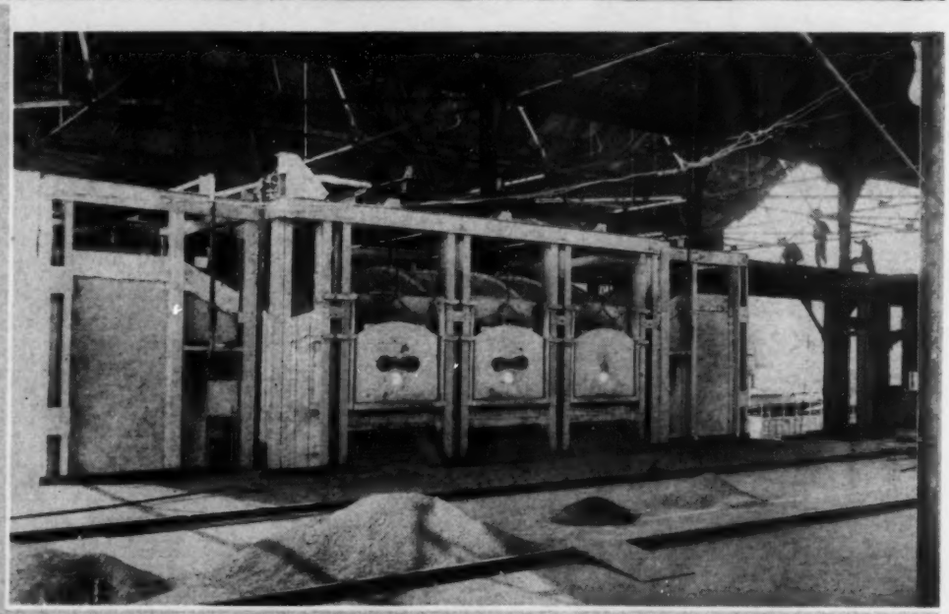
185 Ton
Tilting
OPEN HEARTH
FURNACE



All sizes of Loftus Furnaces are completely engineered for maximum production and minimum fuel consumption.



35 Ton Stationary
OPEN HEARTH
FURNACE

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POSITIONS VACANT
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HUNTER SAW & MACHINE CO.
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PITTSBURGH (Continued)

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Cable Address "FOSTER" Pittsburgh

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Transformers – Timers – Cable Take-up Reels
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All displayed classified advertising is sold in multiples of one inch at the flat rate of $8.00 per column inch. Minimum insertion is one inch. Maximum insertion is one column, 10 inches deep, or two columns, 5 inches deep

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All undisplayed classified advertising is sold at the rate of $1.00 per line. Five line minimum insertion charge. A box number address counts as one line.

Deadline:
All copy must be received by the 20th of the month preceding publication date.

IRON AND STEEL ENGINEER
1010 EMPIRE BUILDING
PITTSBURGH 22, PA.

PITTSBURGH (Continued)

METALLIC RECUPERATORS
(Air Preheaters)
For application to soaking pits, heating, and other types of metallurgical furnaces.
HAZEN ENGINEERING CO.
Park Building PITTSBURGH, PA.

ROBERT T. JOHNSON
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NORTHERN ENGINEERING WORKS
E.O.T. Cranes – Electric Hoists – Air Hoists
THE HILL-ACME CO.
Alligator Shears – Portable Cranes – Special Machinery
Union Trust Building
PITTSBURGH, PA.
Phone: ATlantic 1535

PENNELL ASSOCIATES
Complete Material Handling Systems
O. R. Heidenrich
Investment Building
PITTSBURGH 22, PA.
ATlantic 6734
ELWELL-PARKER ELECTRIC CO.
Electric Industrial Trucks
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ELIZABETH IRON WORKS
Bridge Ramps for Car Loading
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Buda Chore Boy

WHY NOT TAKE ADVANTAGE OF THESE DISTRICT LISTINGS? MANY POTENTIAL CUSTOMERS MAY WANT YOUR PRODUCT OR SERVICE, BUT MAY NOT KNOW WHERE YOU ARE LOCATED.

THE ENGINEERING MART

PRODUCTS
Acid-Proof Materials

Specify SAUEREISEN
ACIDPROOF CEMENTS—COMPOUNDS
FOR
Tanks, Sewers, Stacks, Floors
Technical cements for all purposes.
Send sketches or samples
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Wanted
Steel Rod ¼" to ⅝"
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Nails 6 - 20 penny
MURRAY M. NELSON, INC.
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BUSINESS OPPORTUNITIES

LINES WANTED!

Manufacturers' Agent wants to add electrical lines in Pittsburgh and Youngstown District. Fourteen years industrial sales experience with wide acquaintance in steel industry. Address Box 1101, IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

POSITIONS VACANT

ELECTRICAL ENGINEER, experienced in design, operation, and maintenance of steel mill machinery. Work in England and Europe for large American manufacturer. Address Box 1103, IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

WANTED

Copies of "THE MODERN STRIP MILL" published by the AISE. If your copy is not being used why not sell it? For details write to IRON AND STEEL ENGINEER, Box 1104, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

News Supplement

(Continued from page 146)

PORTER UNIT ACQUIRES MANUFACTURING RIGHTS

▲ The Hinderliter Tool Company division of the H. K. Porter Company, Inc. announces its acquisition of all manufacturing rights for "Nail-It" pipe couplings, "Nail-It" mud guns, "Nail-It" swivel joints and pump suction couplings.

This new coupling principle and sealing method is very unique and is said to be the fastest type of coupling yet devised. The halves of the unit are coupled by driving common nails into mating grooves in the male and female ends and are uncoupled by merely pulling the nails. Two or more nails are used on each coupling to form a removable steel shear ring of greater strength than a regular line pipe joint.

Oil-and-wear resistant synthetic "O"-ring gaskets form pressure tight seals in "Nail-It-Kwik" products. No mechanically applied compression is necessary to effect a seal, and scarring or abrasion of the sealing surfaces will not cause leakage, as the "O"-rings seal between, not on, mating surfaces.

INTRODUCE CUTTER FOR PRODUCTION MILLING

▲ Kennametal, Inc. has just introduced its axial face "Kennamill" designed especially for production milling of cast iron, and suitable for light to medium cuts on solid or cored castings. This new mill incorporates the advantages of solid blade face mills with maximum number of blades. Set up is easy as blades can be assembled to within a few thousandths on the face and periphery, and they do not move during tightening.

Cutter life between grinds is exceptionally long due to rigid, solid blade construction. Sharpening is simplified because of the open construction of the cutter, freedom from brazing strains, and because there are only three surfaces to grind. The cutter is versatile. It can be mounted on all common spindles with bolt circle provided to order. The body is shaped to permit grinding a 45 degree corner angle for milling light cored sections, and is sufficiently over nominal diameter to cut full width when so ground. Five sizes are now available: 6, 8, 10, 12, and 14 in.

BOOK REVIEW

▲ "F. H. McGraw and Company" published by the company is an elaborate brochure which describes the company's operations, capabilities, and history. The experience and background of some of the key members of the organization are also included. Some of their completed projects include additions to the Irvin Works, construction and installation for a strip mill for Armco, coke oven gas mains and wash oil facilities, changes to some pickle lines, rebuilding of annealing furnaces, erection of some equipment for the 80 in. strip mill at Gary, erection of 18,000-ton hydraulic press for Wyman-Gordon Products, and many other construction and installation jobs.

▲ "Principles of Electrical Engineering," by T. F. Wall, 576 pages, $8.50, is published by the Chemical Publishing Company, Inc., of Brooklyn, New York.

This book, which is written by the head of the electrical engineering department of the University of Sheffield, England, presents a comprehensive but compact account of the basic principles of electrical engineering. Emphasis is placed on problems relating to both heavy-current and light-current engineering practice; and to simplification in methods of solution.

Reduce your Rejects—

assure more uniform gauge with wear-defying N•B•M #200 Bronze Bearings.

Mill superintendents report savings on off-gauge plate and crop end wastage more than offset the cost of these bearings.

Figures supplied by mill after mill prove that N-B-M #200 Bronze gives record-breaking performance over conventional bearings: 10 to 18 times longer service; far greater tonnage; substantial savings in maintenance and power; freedom from cut roll necks.

Why not set some records of your own? Our engineers are ready to help you.

N•B•M
BRONZE AND COPPER CASTINGS

Blast Furnace Copper Castings • Roll Neck Bearings • Slippers • Housing Nuts • Machinery Castings • Babbitt Metals • Acid Resisting Castings Phosphorized Copper

NBM

AMERICAN Brake Shoe COMPANY

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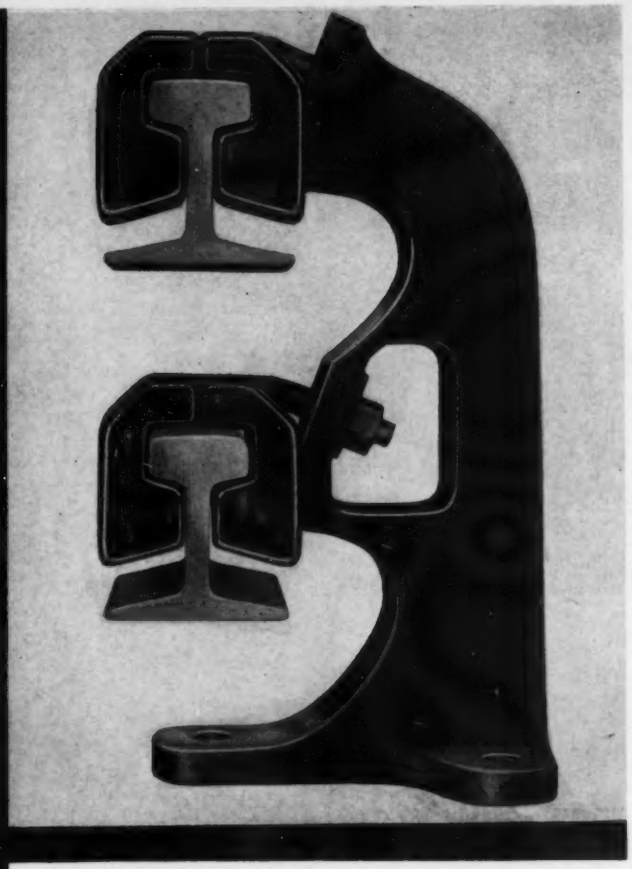
rain . . . snow . . . sleet

POSITIVE POWER

under all conditions



keystone under-contact rail system

From the heat of furnaces to the outside trackage subject to rain, sleet and snow, Keystone Under-Rail Contact Systems have proved their ability for positive transmission of power.

Keystone Under-Rail Contact System is particularly adaptable to industrial work for use in connection with the operation of heavy cranes, conveyors and industrial haulage systems.

The Keystone method of suspending the rail makes it easy to replace a defective or broken insulator without disturbing the balance of the assembly, and, as the rail is loose fitting, the alignment is not affected by contraction and expansion.

For long-lasting, positive transmission of power, specify Keystone. For full details on the many other industrial electrical products manufactured by Keystone, write for complete catalog to . . .

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TRANSPORTATION, POWER AND INDUSTRIAL PRODUCTS

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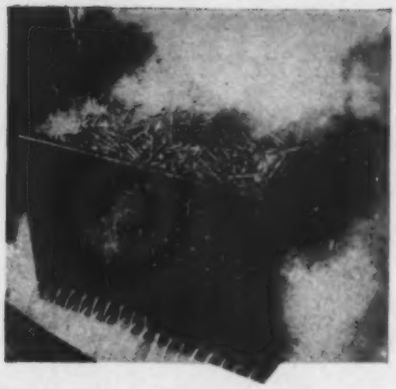
SHEET • BAR • ROD • FLAT • ANGLE • HALF-ROUND • HEX • WIRE • ROUND • SHEET •

How shall I Use Monel To Make the Best Pickling Basket?

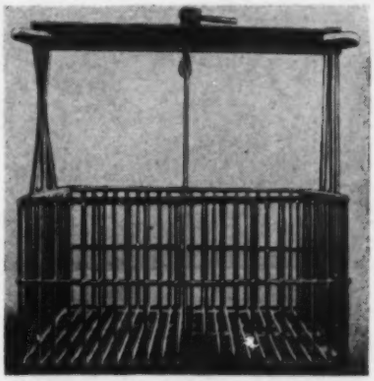
There are as many answers as there are standard mill forms of Monel*

COME ALONG AND SEE WHY . . . .

SHEET • BAR • ROD • FLAT • ANGLE • HALF-ROUND • HEX • WIRE • ROUND • SHEET •

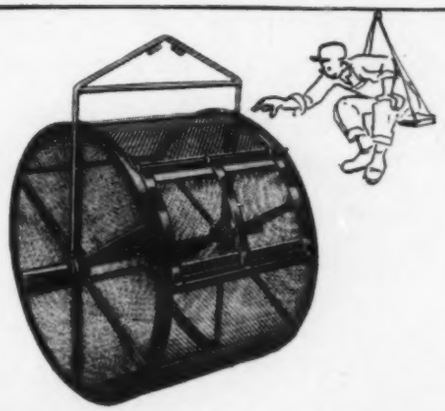


1. HERE'S A 307-POUND WELDED BASKET of perforated Monel* sheet. Capacity 2,500 pounds of bolts —10% more than the same size wood basket it replaced. Sharp edges can't chew into Monel. Metal construction gives easy acid flow and prevents uneven pickling.

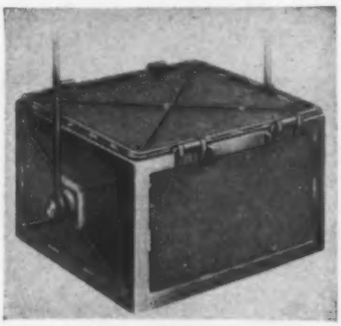


2. NEXT, A SIMPLE AND STURDY BASKET. Made entirely of corrosion-resistant Monel bar, it was welded by ordinary shop methods. The pin at top center is for hooking onto an overhead conveyor. Side index plates lock into the conveyor when the basket is carried. With a tensile strength of 80-95,000 psi, hot rolled Monel bar is a wise—and safe—choice for a job like this.

3. A COMBINATION OF THREE FORMS of Monel — screen, sheet and bar. This revolving basket weighs 220 pounds, and has a capacity of more than 500. The unique top fastening permits fast and *complete* dumping. Because of Monel's toughness and ductility, a basket like this stays in service long after others have hit the scrap heap.



4. STILL ANOTHER combination, this time of Monel angles and flats, welded together and covered with Monel wire cloth. Hanger and shaft are Monel rod. In all forms, Monel provides high resistance to pickling solutions commonly used by steel mills.



5. SMALL PARTS won't hop out of this all-Monel basket. *They're locked in.* The basket lid is easily removed for loading and unloading.

*Reg. U.S. Pat. Off.

Whether you pickle bulky hollow ware, heavy forgings or small stampings, it's easy to build strong, long-lasting baskets that exactly meet your needs.

Use standard mill forms of

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street, New York 5, N. Y.

Monel* EMBLEM OF SERVICE INCO TRADE MARK

HARDENED AND GROUND FORGED STEEL ROLLS

Need rolls for your tin plate, strip or sheet mill . . . for rolling precious metals, copper, aluminum . . . synthetic materials? Look to Midvale if you want hardened and ground forged steel rolls built to your own high standard of quality. Midvale rolls are superior rolls—as your experience will prove. The reason—Midvale workmanship, care and knowledge, all contribute to the finished product.

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MIDVALE

Custom Steel Makers to Industry

STAINLESS AND TOOL STEEL BARS

•

CORROSION AND HEAT RESISTING CASTINGS

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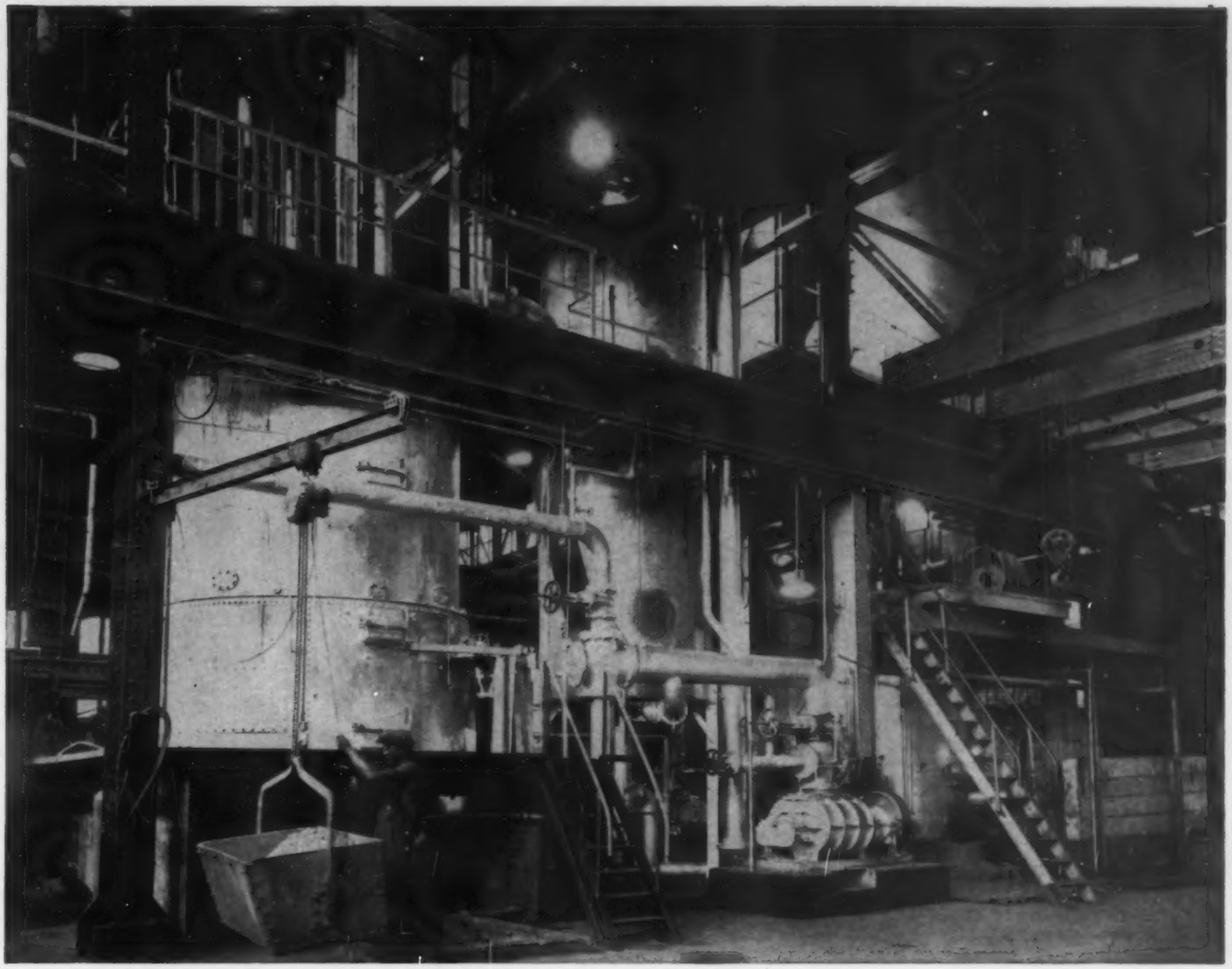
FORGINGS AND RINGS



This WELLMAN-GALUSHA CLEAN GAS GENERATOR

has been operating 24 hours a day, 7 days a week, since 1929

WELLMAN Will Build It!

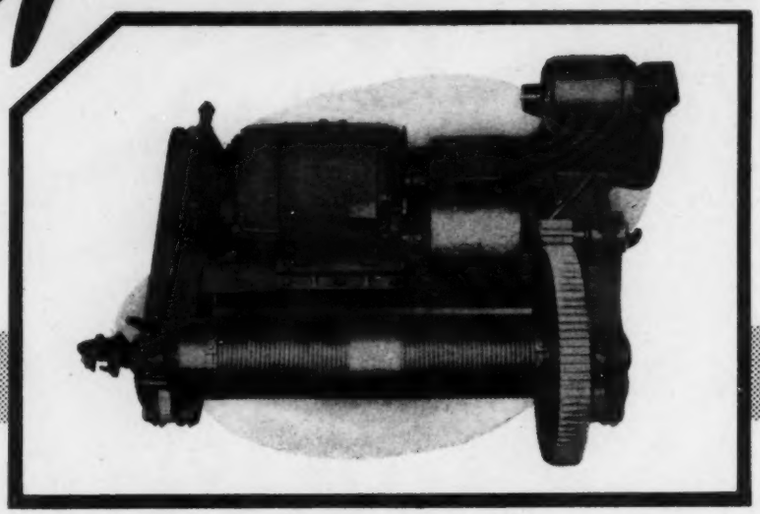
- Car Dumpers
- Gas Producer Plants
- Gas Flue-Systems
- Gas Reversing Valves
- Coke Pushers
- Mine Hoists
- Skip Hoists
- Ore Bridges
- Clamshell Buckets

STILL GOING STRONG after seventeen years of service—that's a typical performance record for this famous Generator! Wellman-Galusha Generators supply low-cost fuel for heating and heat-treating furnaces in steel and non-ferrous metal industries—glass melting and annealing, kilns and furnaces for the ceramic industry—also used where chemical processes require gas of unusual composition for reduction of oxides and for synthesis of various chemical products, and for gas engines, stationary or marine.

THE WELLMAN ENGINEERING COMPANY

7031 CENTRAL AVENUE • CLEVELAND 4, OHIO

Stop OIL SHOWERS FROM CRANE MOTORS



WITH NON-FLUID OIL

TRADE MARK REGISTERED

Constant oil and grease leakage from overhead crane motors not only results in high lubricant and application costs but also stock cleaning costs are increased when oil deposits must be removed. In fact, on sheet metal products it is virtually impossible to remove these spots in the pickling process or even when the sheets are annealed.

The answer? NON-FLUID OIL . . . saves time and money because it does not drip or leak. You get *clean* lubrication and *clean* products at lower cost.

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"Prior to using NON-FLUID OIL, we had trouble daily with our machines running hot and corroding. Since changing to NON-FLUID OIL, we have not had any trouble."

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"If it isn't Wide Enough It isn't Good Enough"

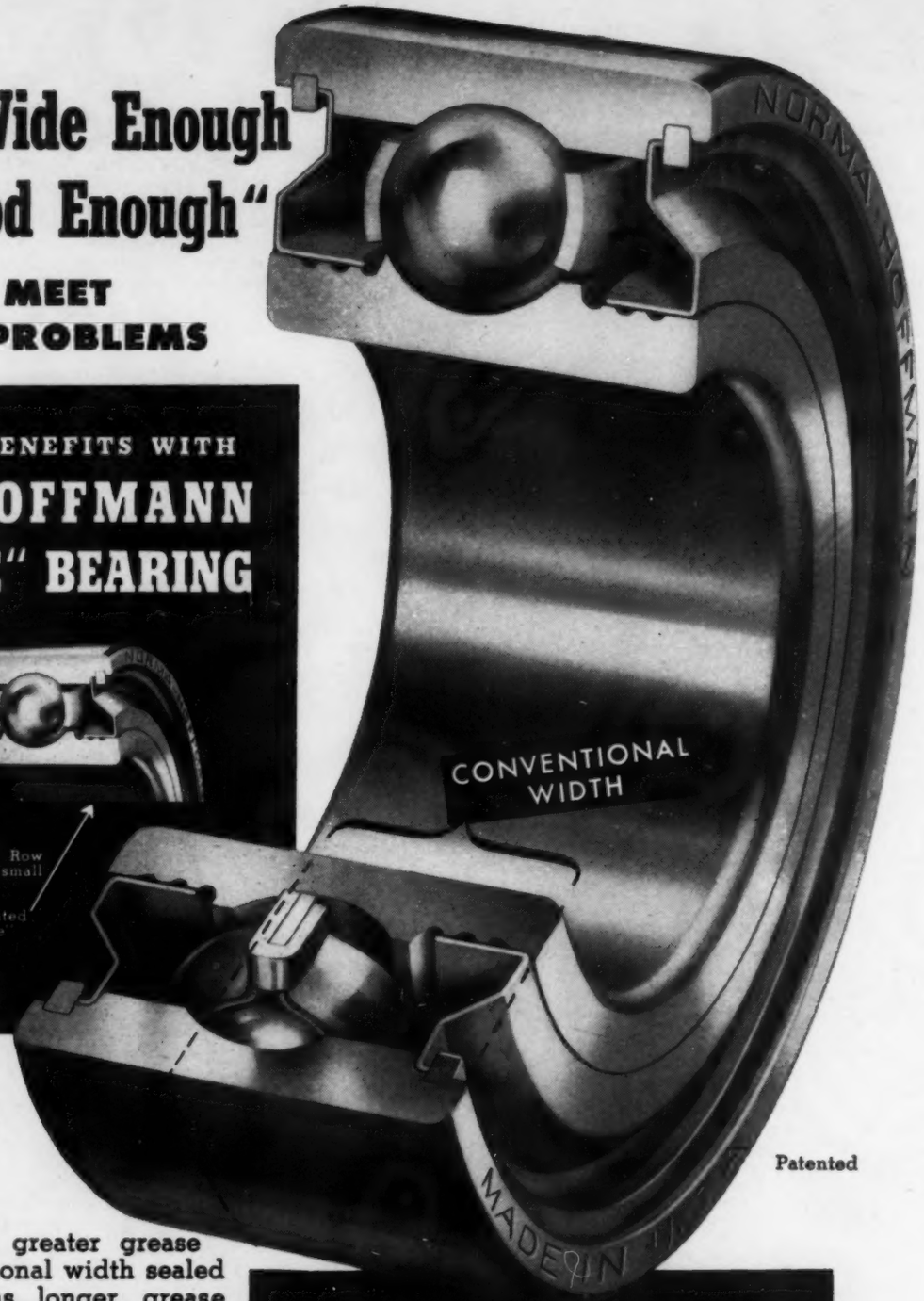
...TO MEET TODAY'S PROBLEMS

GET 3 DESIGN BENEFITS WITH

NORMA-HOFFMANN "CARTRIDGE" BEARING

CONVENTIONAL Single Row Width sealed bearing has small grease capacity.

NORMA-HOFFMANN patented double row width "Cartridge" Bearing has 100% greater grease capacity.



Patented

Here's What You Get

1. **Longer Life** A 100% greater grease capacity than conventional width sealed bearings. This means longer grease life... longer periods between relubrication—because a large volume of grease does not oxidize or dry out as readily as a thin film of grease.
2. **Greater Contact Area** 43% to 85% greater contact area between shaft and bearing bore and between housing and bearing O.D., as compared to conventional width bearing. This eliminates need for locknuts and results in greater shaft strength as it is unnecessary to cut locknut threads. Slippage and peening are also prevented.
3. **Full Load Carrying Capacity** Unlike many other sealed bearings, *full size* balls are used; hence, there is no reduction in load carrying capacity.

America's No. 1 SEALED BEARING by NORMA-HOFFMANN

NORMA-HOFFMANN BEARINGS CORPORATION, STAMFORD, CONNECTICUT

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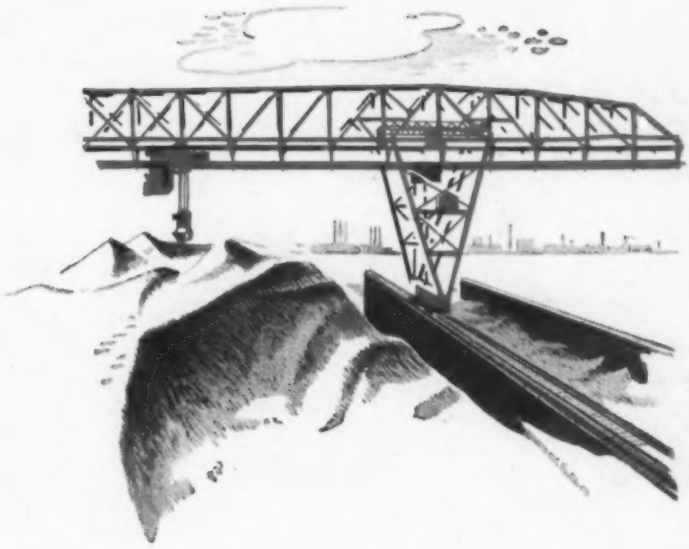
$6090 loss charges for broken yokes cut to $435

IN a single season at a steel company's unloading dock, the ore bridges broke 14 yokes on the bucket controls. New parts for each replacement cost $50. But far more serious was the 3½ hours' time lost in replacing each yoke — time charged for at the rate of $10 an hour, plus $100 an hour more for the boat delay. Investigation showed that improper lubrication was causing the trouble—a recurring expense of $435 per break, or a total of $6090 loss for one season.

Farval Centralized Lubricating Systems, installed on the six ore bridges, solved the lubrication problem. Since then only one yoke has been broken. Thus an annual loss from broken yokes has been reduced from $6090 to only $435. The first season's saving more than paid for Farval.

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, as often as desired. Farval is the Dualine System with the Positive Piston Displacement Valve. This valve has but two moving parts and is fully adjustable, with a Tell-tale indicator at each bearing to show the job is done. For a full description of Farval, write for Bulletin 25, The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing.
In Canada: Peacock Brothers Limited.



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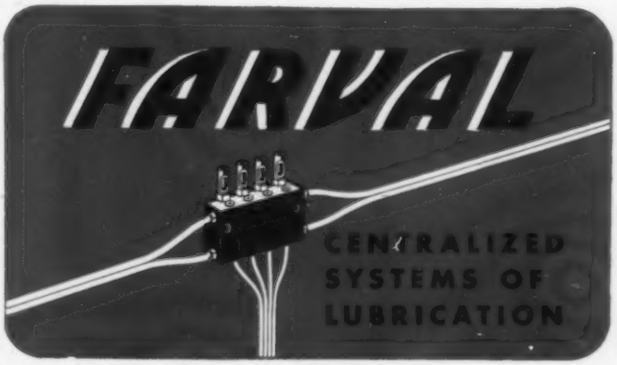
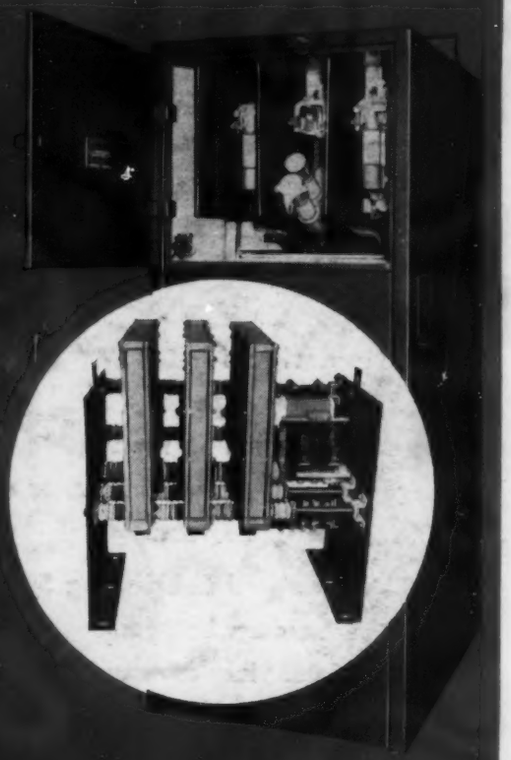


Motors are hard to get...

Guard them with LIMITAMP CONTROL



Limitamp control is furnished as a single unit, in groups, or in special enclosures for special operating conditions.

Limitamp control can provide those hard-to-get motors with sure, short-circuit protection. In less than *one-quarter* cycle, Limitamp's EJ-2 fuses cut off a rise in current from a short, and clear it in one-half cycle—long before the short has time to harm the contactor or motor. Your plant's power system needs this prompt handling of fault currents, and you will avoid the risk of costly shutdowns that can result from just *one, mad short circuit.*

A STARTER AND PROTECTOR IN ONE CABINET

G-E Limitamp control consists of an airbreak contactor (the motor starter), and EJ-2 fuses (the short-circuit device). They are mounted in separate compartments of one, all-steel cabinet.

Airbreak contactors are specially designed for hard duty. Operating experience has proved they furnish long-lived, low-cost service with only routine maintenance.

Because they operate in air, they eliminate the problem of handling oil. And tip life of airbreak contactors is many times that of comparable oil-immersed tips.

You can depend on EJ-2 fuses for sure, short-circuit protection. They are "fail-safe" devices. There is nothing about them to wear. They are easy to replace.

OVERLOAD AND UNDERVOLTAGE PROTECTION

Isothermic overload relays, accurately calibrated against actual motor characteristics, guard the motor against overheating from sustained loads or single phasing.

FACTORY-ASSEMBLED CONTROL

Factory-assembled in one cabinet, Limitamp is easy to install, easy to co-ordinate with other control, saves space, and improves the appearance of your plant.

The Trend is to AIR

G-E LIMITAMP . . . THE FIRST HIGH-VOLTAGE CONTROLLER WITH AIRBREAK CONTACTORS

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Please send me Bulletin GEA-4247 on Limitamp control.

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